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THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING THE PROCEEDINGS

MAY 1911

SPRING MEETING, PITTSBURG, MAY 30—JUNE 2.
MONTHLY MEETINGS: NEW YORK, MAY 9;
BOSTON, MAY 17.

C. W. Hunt.

PRESIDENT 1898

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MAY 1911 VOL. 33 No. 5

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OF
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The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 MAY 1911 NUMBER 5

THE SPRING MEETING

Plans for the Spring Meeting, to be held in Pittsburg, Pa., May 30–June 2, are rapidly being matured, and the following tentative program is announced. The professional sessions at which such important questions as the application of mechanical engineering to cement manufacture, and the phases of steel works' practice involved in turbo-compressors and forging presses, should prove of unusual value and interest, together with the technical excursions arranged to supplement the papers which will be presented on these and other topics. As already announced, the Hotel Schenley will be the Society headquarters during the Convention and the professional sessions will be held at the Carnegie Institute. An invitation from the Engineers' Society of Western Pennsylvania for a smoker and entertainment to be held in their rooms on Friday evening, June 2, has been accepted by the Society with much appreciation.

PROGRAM

Tuesday Morning and Afternoon, May 30

Registration and reunion of members in the parlors of the Hotel Schenley.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Tuesday Evening

Informal reception for the members and ladies of the Society in the parlors of the Hotel Schenley.

Wednesday, May 31, 10 a. m.

MECHANICAL ENGINEERING OF CEMENT MANUFACTURE

Edison Roll Crushers, W. H. Mason.
Some Problems of the Cement Industry. Walter S. Landis.

Wednesday Afternoon

Excursion by special train to the plant of the Universal Portland Cement Company, Universal, upon invitation of Mr. E. M. Hagar, President.

The train will stop at East Pittsburg, both going and returning, to permit those who desire to inspect the works of the Westinghouse Electric & Manufacturing. Co. and the Westinghouse Machine Co.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Wednesday Evening, 8.30

MACHINE SHOP SESSION

The Assembling of Small Interchangeable Parts, John Calder.
Process of Assembling Small and Intricate Parts, Halcolm Ellis.
The Design of Milling Cutters and Their Efficiency, A. L. De Leeuw.

GAS POWER SESSION

Papers to be announced.

Thursday, June 1, 10 A. M.

MISCELLANEOUS SESSION

Stresses in Tubes, Reid T. Stewart.
Purchase of Coal on the Heat Unit Basis, D. T. Randall.

Energy and Pressure Drop in Compound Steam Turbines, F. E. Cardullo.

Pressure Recording Indicator for Punching Machinery, G. C. Anthony.

Thursday Afternoon

Boat excursion up the Monongahela River for members and ladies, including inspection trip to the National Tube Company's works at McKeesport.

Thursday Evening

Reception and dance at the Hotel Schenley.

Friday, June 2, 10 A. M.

STEEL WORKS PRACTICE

Commercial Application of the Turbine Turbo-Compressor, R. H. Rice.

Also papers on Blowing Engines and Hydraulic Forging Presses.

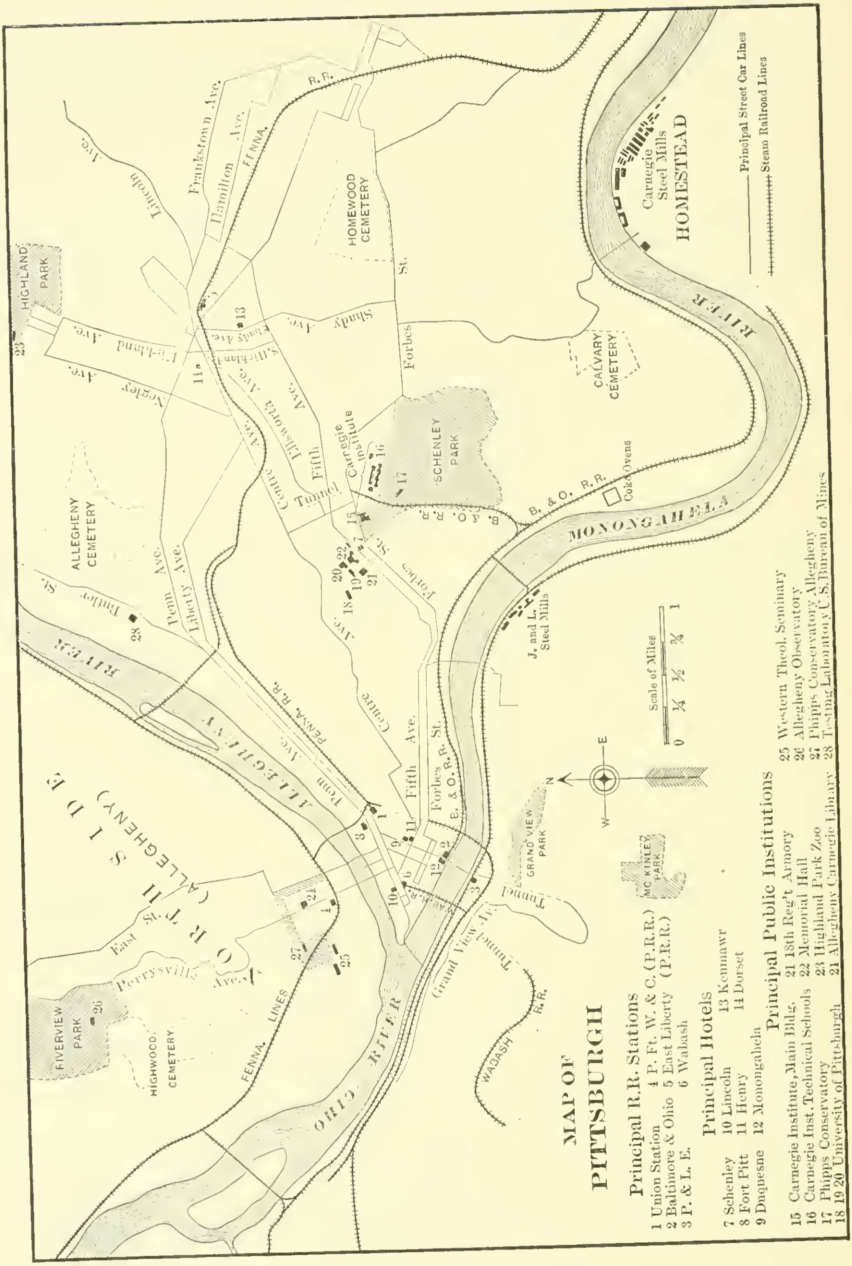
Friday Afternoon

Inspection trip to Mesta Machine Company's works at Homestead.

Friday Evening

Smoker and entertainment given in honor of The American Society of Mechanical Engineers by the Engineers' Society of Western Pennsylvania in their rooms in the Oliver Building.

A program of entertainment for the visiting ladies is also in preparation by the Ladies' Committee, Mrs. Chester B. Albree, Chairman, which includes in addition to the events above scheduled on the general program to which ladies are invited, the inspection of the Margaret Morrison School for Women of the Carnegie Technical Schools on Wednesday morning, with luncheon at the Pittsburg Golf Club. Tea will be served at the Twentieth Century Club on Wednesday afternoon, as an alternative entertainment to the trip to East Pittsburg. In the evening a visit will be made to the Carnegie Art Galleries, where the Annual Exhibit will be in progress. On Thursday


MAP OF
PITTSBURGH
Principal R.R. Stations
1 Union Station
2 Baltimore & Ohio
3 P. & L. E.
4 P. Ft. W. & C. (P.R.R.)
5 East Liberty (P.R.R.)
6 Wabash
Principal Hotels
7 Schenley
8 Fort Pitt
9 Duquesne
10 Lincoln
11 Henry
12 Monongahela
13 Kenmawr
14 Dorset
Principal Public Institutions
15 Carnegie Institute, Main Bldg.
16 Carnegie Inst. Technical Schools
17 Phipps Conservatory
18 19 20 University of Pittsburgh
21 18th Reg't Armory
22 Memorial Hall
23 Highland Park Zoo
21 Allegheny Carnegie Library
25 Western Theol. Seminary
26 Allegheny Observatory
27 Phipps Conservatory Allegheny
28 Testing Laboratory U.S. Bureau of Mines
Scale of Miles
0
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½
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1
Principal Street Car Lines
Steam Railroad Lines
N
E
W
HOMESTEAD
Carnegie Steel Mills
MONONGAHELA RIVER
ALLEGHENY RIVER
OHIO RIVER
NORTH SIDE (ALLEGHENY)
HIGHLAND PARK
SCHENLEY PARK
HOMEWOOD CEMETERY
CALVARY CEMETERY
ALLEGHENY CEMETERY
RIVERVIEW PARK
HIGHWOOD CEMETERY
GRAND VIEW PARK
MC KINLEY PARK
Coke Ovens
J. and L. Steel Mills
Carnegie Institute
B. & O. R.R.
PENNA. R.R.
PENNA. LINES
WABASH R.R.
R.R.
Tunnel
Grand View Av.
Frankstown Ave.
Hamilton Ave.
Lincoln Ave.
Highland Ave.
Negley Ave.
Shady Ave.
S. Highland Ave.
Ellsworth Ave.
Centre Ave.
Fifth Ave.
Forbes St.
Penn Ave.
Liberty Ave.
Butler St.
East St.
Perrysville Ave.

morning Carnegie Institute and the new Athletic Club will be open to inspection and on Friday morning the Heinz Pickle Works. On Friday there will also be automobile drives through the beautiful East End Parks and to Sewickley, with tea served at the Allegheny Country Club.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Pittsburg, May 30 to June 2, 1910.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 26 and June 1 inclusive. At the same time request a certificate, *not a receipt*. This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager at the Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after June 2.

d An agent of the Trunk Line Association will validate certificates, May 31, June 1, 2. No refund of fare will be made on account of failure to have certificate validated.

e One-hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to June 6, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:
The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland; also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

The New England Passenger Association except via Eastern Steamship Co.

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

LOCAL COMMITTEE

E. M. Herr, *Chairman*
Elmer K. Hiles, 2511 Oliver Bldg., *Secretary*
George Mesta, Chairman Committee on Finance
John M. Tate, Chairman Committee on Entertainment
Chester B. Albree, Chairman Committee on Hotels
Morris Knowles, Chairman Committee on Printing
D. F. Crawford, Chairman Committee on Transportation
Mrs. Chester B. Albree, Chairman Ladies' Committee

HOTEL RATES FOR SPRING MEETING AT PITTSBURG

Minimum Rates

	Without Bath			With Bath		
	Single Room	Single Room Two Persons	Double Room Two Persons	Single Room	Single Room Two Persons	Double Room Two Persons
Hotel Schenley	$2.00	$3.00	$——	$3.00	$4.00	$5.00
Fort Pitt Hotel	1.50	——	2.50	2.50	——	3.50
	2.00	——	3.00	5.00		7.00
Hotel Henry	1.50	2.50	3.00	2.50	3.50	4.00
	2.00	up	up	up	up	up
Monongahela House	1.50	——	2.00	2.50	——	4.00
	2.00		3.00	3.00		5.00
Hotel Anderson	1.00	1.50	3.00	2.50	——	4.00
		2.00	4.00	3.50		
Duquesne Hotel	1.50	——	2.50	2.50	——	3.50
Hotel Lincoln	1.50	——	2.00	2.00	——	3.00
	2.50	——	4.00	3.00		5.00
Seventh Avenue Hotel	1.50	2.50	3.00	2.50	4.00	5.00
Colonial Annex Hotel	1.50	2.00	2.50	2.00	3.00	3.50
						5.00
The Dorset	1.00	——	2.00	2.00	——	3.00
Hotel Lorraine*	2.50	——	4.00	3.00	——	5.00
				3.50		6.00

*American plan.

MONTHLY MEETINGS

NEW YORK MEETING, MAY 9

The subject to be considered at the New York meeting of the Society, to be held in the Engineering Societies Building on Tuesday evening, May 9, will be Patents. The purpose of the meeting is to outline to the engineer and manufacturer the fundamental principles of the patent law, the position and qualifications of a patent expert, and the industrial development for the purpose of establishing a patent monopoly. The whole question is rather one of pure and applied science than of law and for this reason interests engineers and those trained in the mechanic arts. It will be treated by such experts as E. W. Marshall, D. Howard Haywood, and Edwin J. Prindle, all of New York City, and will be discussed by a number of engineers and patent experts. The members of the Inventors' Guild have been especially invited to attend.

BOSTON MEETING, MAY 17

A meeting of the Society in Boston will be held on May 17 and will be conducted by the Boston Section of the American Institute of Electrical Engineers. A paper entitled, The Electric Motor in the World's Work, will be read by the author, Fred. M. Kimball, Associate A.I.E.E., manager of the small motor department of the General Electric Company, West Lynn, Mass.

PHILADELPHIA MEETING, JUNE 3

On account of the interest manifested on the subject of Fuel Testing, considered at the meeting in Philadelphia on April 22, when a paper by J. C. Parker of that city on the Work of the United States Fuel Testing Station was presented, the meeting on June 3 in that city will be given up to further discussion of the same topic. As this will follow immediately after the Spring Meeting in Pittsburg, members passing through Philadelphia will have an opportunity to be present and to take part in the discussion. The Engineers Club of Philadelphia will coöperate in the meeting.

ST. LOUIS MEETING, MARCH 25

A special meeting of the members of the Society in St. Louis was held on March 25, to meet President Meier, who gave an interesting talk on the various questions concerning the meetings of the Society in different cities and the proposed rules governing these meetings which are now being established in the various localities. It was the sense of the meeting that the rules as proposed would be very satisfactory. It was moved and carried that an assessment be levied on the local membership to defray expenses incidental to meetings other than those called to consider technical subjects.

NEW YORK MEETING, APRIL 11

At a meeting of the Society in New York on April 11, agricultural machinery, with particular attention to the farm tractor, was the subject for consideration. L. W. Ellis, traction plowing specialist of the M. Rumely Company, La Porte, Ind., presented a paper on The Economic Importance of the Farm Tractor, which he regards as the solution of the present-day problems of the farm. This presentation was followed by a talk by Charles E. Lucke on the mechanical equipment of farm tractors, illustrated by views taken at the Canadian Industrial Exhibition held in Winnipeg, Manitoba, last summer, at which Dr. Lucke represented the International Harvester Company. Many questions concerning the various farm implements under discussion were answered by Dr. Lucke and Mr. Ellis. Written discussions of the paper by Mr. Ellis were submitted by G. W. Perry, sales manager of the Holt Caterpillar Company, Peoria, Ill.; by Putnam A. Bates, New York City; J. B. Davidson, professor of agricultural engineering, Iowa State College; George T. Powell, president of the Agricultural Experts Association, New York City; and O. B. Zimmerman, mechanical engineer of the M. Rumely Company, La Porte, Ind.

BOSTON MEETING, APRIL 21

At the meeting of the Society in Boston on April 21, the Boston Section of the American Institute of Electrical Engineers and the Boston Society of Civil Engineers coöperating, B. R. T. Collins, Mem. Am.Soc.M.E., with the Stone & Webster Engineering Corporation, Boston, presented his paper on Oil Fuel for Steam Boilers, dealing with the possible use of oil fuel for steam generating purposes in the Atlantic Coast states, its safety and permanency of supply, as well as conditions under which it may have special advantages over coal. The paper was discussed by E. H. Peabody, Mem Am.Soc.M.E., of the marine department, Babcock & Wilcox Co., New York; D. S.

Jacobus, Mem.Am.Soc.M.E., advisory engineer of the Babcock & Wilcox Co.; M. H. Bronsdon, chief engineer of the Rhode Island Co., Providence, R. I.; Edw. Robinson, Mem.Am.Soc.M.E., professor of mechanical engineering, University of Vermont; S. F. McIntosh, general engineer, American Optical Co., Southbridge, Mass.; Robt. C. Monteagle, Mem.Am.Soc.M.E., chief engineer of the Atlantic Works, East Boston; C. F. Dietz, Mem.Am.Soc.M.E., consulting engineer, Dietz & Keedy, Boston; F. J. Carty, with the Stone & Webster Engineering Corporation, Boston; F. C. Hovey, with Charles T. Main, Boston; J. C. Riley, Mem.Am.Soc.M.E., assistant professor of mechanical engineering, Massachusetts Institute of Technology; D. W. Robb, Mem.Am.Soc.M.E., president of the Robb Engineering Co., Ltd., Amherst, Canada; C. F. Baker, Mem.Am.Soc M.E., Newton, Mass.; C. H. Parker, Mem.Am.Soc.M.E., assistant superintendent of the generating department, Boston Edison Co., Boston; and E. F. Miller, Mem.Am.Soc.M.E., professor of steam engineering, Massachusetts Institute of Technology. Professor Miller presided over the meeting, at which there was an attendance of 90.

PHILADELPHIA MEETING, APRIL 22

A meeting of the Society was held at the Engineers Club in Philadelphia on Saturday evening, April 22, with an attendance of 30. The paper of the evening, on the Work of the United States Fuel Testing Station, was presented by the author, J. C. Parker, general manager of the Parker Boiler Co., Phila. He showed numerous slides giving curves plotted from the results published by the United States Fuel Testing Station. A. S. Mann, fuel expert of the General Electric Company, Schenectady, N. Y., James Christie, consulting engineer, of Philadelphia, Francis Head, mechanical engineer, of the Bureau of Water, Philadelphia, and A. C. Wood, consulting engineer, of Philadelphia, discussed the paper.

BILL FOR LICENSING ENGINEERS

Col. E. D. Meier, President, and C. W. Rice, Secretary, attended a meeting of engineers on February 16, to consider the subject of laws for licensing engineers. Members of the American Society of Civil Engineers, the American Institute of Electrical Engineers, and the American Institute of Mining Engineers were present at the meeting and unanimously adopted the following resolution:

> Whereas, the engineering profession is threatened with the passage of a Licensing Bill at Albany by the New York State Legislature, and
>
> Whereas, the legislation proposed by the bills now in committee will operate to the serious disadvantage of our profession and the business interests of the State;
>
> Now, therefore, be it resolved, That it is the unanimous opinion of the undersigned that it is to the interest of the engineering profession and the public that no license bill whatever be passed and that the presidents of the engineering societies be requested to appear in person, or by representative, at Albany at any of the hearings before the legislative committee which has the matter in charge, and vigorously oppose the passage of any bill for licensing engineers; and also that the various representatives of the societies, as above, shall get together to insure co-operative action.

Cary T. Hutchinson
William Barclay Parsons
Allen Hazen
W. J. Wilgus
A. A. Stuart
Ralph Chambers
Henry W. Hodge
Calvin W. Rice
Charles Whiting Baker
Alfred P. Boller
L. B. Stillwell

S. L. F. Deyo
Rudolph Hering
Ralph D. Mershon
H. de B. Parsons
Samuel Whinery
A. W. K. Billings
George B. Francis
Frank J. Sprague
E. D. Meier
R. S. Buck

These resolutions were printed and distributed among the engineers of New York State.

On March 1, the Hoff Bill was considered by the Committee of the Assembly on General Laws. The bill was opposed in short speeches of five minutes each by Col. E. D. Meier, President Am. Soc. M. E., A. P. Boller, R. S. Buck, E. G. Spilsbury, Mem.Am.Soc.M.E., G. B. Francis, F. J. Sprague, and P. C. Ricketts, Mem.Am.Soc. M.E., who spoke against any and all bills; and by Judge Danneher, retained by the Technical League of America, who opposed only the Hoff Bill and announced his intention of favoring the McGrath Bill. Mr. Tillson, representing the Brooklyn Society of Municipal Engineers, was the only one in favor of the Hoff Bill.

On March 14, a special committee again appeared before the Committee on Public Education to consider the McGrath Bill. Mr. Elliot, President of the Technical League of America, and Judge Danneher, counsel for the League, spoke in favor of the bill but offered to cut out each item to which the speakers raised objection. The principal speakers against the Bill were Mr. Merritt, minority leader in the House, James M. Dodge, Chairman of the Committee on Public Relations of the Society, Dean R. C. Ricketts, Mem. Am. Soc. M. E , representing Cornell, Rensselaer and Syracuse Universities, and Alfred P. Boller, Col. E. D. Meier, President Am.Soc.M.E., E. G. Spilsbury, Mem.Am.Soc.M.E., Frank J. Sprague. A resolution passed by the Engineering Society of Eastern New York, against any and all engineers' license bills, was presented by their secretary.

A special committee of engineers appointed by the General Committee, consisting of Col. E. D. Meier, President Am. Soc. M. E., Chairman, Alfred P. Boller, R. S. Buck, C. W. Baker, Mem.Am. Soc.M.E., George B. Francis, E. G. Spilsbury, Mem.Am.Soc. M.E., and Frank J. Sprague, is now collecting information in regard to the Hoff Bill, with a view to bring pressure to bear to defeat it. The principal danger in laws of this kind lies in the fact that if New York passes such a bill, many, if not all, of the other States will follow, and this will prove a tremendous burden on all engineers who have occasion to do professional work in different States, as reciprocity among them all will be difficult to obtain. It is proposed that when the question has been settled in New York State, the main arguments evolved in the discussion shall be printed and sent to the membership of the national societies, with the suggestion that they use these facts in opposing similar Bills hampering the profession in their States.

STUDENT BRANCHES

COLUMBIAN UNIVERSITY

At a meeting of the Columbia University Student Branch, April 3, Prof. C. W. Thomas, Mem.Am.Soc.M.E., delivered an illustrated lecture on The Manufacture of Paper and the Details of Paper Machinery.

CORNELL UNIVERSITY

On March 1, the paper by F. H. Varney, Test of a 9000-Kw. Turbo Generator Set, was read before the Sibley College Student Branch. Tests made by Prof. C. R. Carpenter, Mem.Am.Soc. M.E , at Richmond, Va., and at the Gold Street Station of the Brooklyn Edison Illuminating Company were also described. Col. E. D. Meier, President of the Society, addressed the meeting held March 17. He urged the students to get into touch with the national engineering societies and concluded with some interesting reminiscences of engineering during the Civil War.

OHIO STATE UNIVERSITY

Two papers taken from The Journal of the Society, one on Boiler Explosions by Mr. Allen and another on Safety Appliances by Mr. Pohlman, were read and discussed before the Ohio State University Student branch at a meeting held March 21. Frederick W. Ives, Jun.Am.Soc.T.E., described the work of the University of Wisconsin Student Branch.

POLYTECHIC INSTITUTE OF BROOKLYN

Dr. D. S. Jacobus, Mem.Am.Soc.M.E., gave an illustrated lecture on Power Plant Economics before the Polytechnic Institute of Brooklyn Student Branch at their meeting, April 3. On April 8 an excursion to the Metropolitan Building to inspect the power plant was made.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch held March 25, A. E. Stuart, of the law firm Stuart, Hammond and Simms, representatives of the Wabash Railroad, talked on the The Law as It Applies to the Engineer. He touched on the law on rights, law relating to fixtures, mechanic's lien and the engineer as an expert witness. On April 11, M. J. Golden, Mem.Am.Soc.M.E., gave a lecture illustrated by lantern slides, upon several types of coke ovens.

STEVENS INSTITUTE OF TECHNOLOGY

At the meeting of the Stevens Institute of Technology Student Branch on March 16, Arthur F. Requa presented a paper upon the subject of Block Signalling. On March 24, at the annual dinner of the society, the following addresses were made: Engineering Efficiency, C. R. Schroeder; Engineering and the Public, Mr. Bauhan; Production or Industrial Engineering, H. H. Haynes; The Stevens Engineering Society, W. G. H. Brehmer; The Parting of the Ways, E. O. Hickstein.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held a meeting, April 7, at which E. F. Otting read a paper on System in a Modern Machine Shop. A paper by J. T. Rowell on The Humphrey Pump was also presented and both were followed by a general discussion by the members present.

UNIVERSITY OF ILLINOIS

At a meeting of the University of Illinois Student Branch held April 11, D. S. Knauss discussed The Application of the Slide Rule in the Machine Shop and J. N. Todd related his experiences in a foundry and machine shop.

UNIVERSITY OF MAINE

On February 18, the University of Maine Student Branch, together with the Maine branch of the American Institute of Electrical Engineers, visited the plant of the Bar Harbor and Union River Power Company at Ellsworth. At a meeting on March 18, C. C. Douglass, Mem.Am.Soc.M.E., addressed the members on the subject of Steam Turbines.

UNIVERSITY OF MISSOURI

The paper by John Calder on The Mechanical Engineer and Prevention of Accidents was presented and discussed by A. C. Edwards at a meeting of the University of Missouri Student Branch, on April 3.

UNIVERSITY OF WISCONSIN

The University of Wisconsin Student Branch held a meeting March 16 at which George A. Orrok, Mem.Am.Soc.M.E., talked on Blast Furnace Gas and Its Use in Internal-Combustion Engines.

YALE UNIVERSITY

At a meeting of the Yale Mechanical Engineers Club held April 4, Calvin W. Rice, Secretary of the Society, gave an illustrated lecture on the trip taken by the Society to England during the summer of 1910. The election of officers from the Junior class for next year resulted as follows: F. M. Jones, President; W. St. C. Childs, Secretary and Treasurer; T. Hyde, E. R. Shenk and D. T. Beale, Jr., Governing Board. The Senior members of the society residing in New Haven were invited to attend the meeting, and they decided to hold two meetings each year in connection with the regular meetings of the Student Branch. E. S. Cooley was elected chairman of this body and E. H. Lockwood, secretary.

MEETING OF THE COUNCIL

A meeting of the Council was held on April 10, at the Society rooms, with the President in the Chair. There were present, Charles Whiting Baker, D. F. Crawford, George M. Brill, R. M. Dixon, James Hartness, Stanley G. Flagg, E. B. Katte, I. E. Moultrop, H. G. Reist, Jesse M. Smith, H. G. Stott, H. H. Vaughan, Wm. H. Wiley and the Secretary. Regrets were received from W. F. M. Goss, A. C. Humphreys, W. J. Sando.

The following deaths were reported: Paul Raymond Brooks, George B. Caldwell, A. L. Hammarberg, F. L. Hart, Everett H. White D. B. Wilson, Charles Wallace Hunt, Past-President.

Jesse M. Smith offered the following resolutions on the death of Charles Wallace Hunt.

Charles Wallace Hunt, Past-President of The American Society of Mechanical Engineers, passed away on March 27, 1911, after twenty-six years of active and effective service as a member, officer, President and Past-President of the Society; and

Whereas the Council in session after this blow has befallen the Society is desirous to record its sorrow and sense of loss and its sympathy with those to whom this bereavement has come so sorely close;

Be it resolved that the Honorary Secretary be requested to prepare a memorial notice to be published in The Journal with a portrait of Mr. Hunt; and be it further resolved that this minute commemorative of the great and notable services of Mr. Hunt to the Society be similarly published, and a copy of both be transmitted by the Secretary to Mrs. Hunt and the family with expressions of the keen and profound sympathy of Mr. Hunt's friends in the burden in which they are called on to bear.

Voted: That Mr. Smith be appointed a committee to transmit the above resolutions to Mrs. Hunt.

Professor Hutton offered a memorial notice, which appears elsewhere in The Journal.

That the following new By-Law be adopted, the required thirty days' written notice having been given:

> B 23 The Committee on Meetings shall consist of five persons who may be members of any grade. The term of office of one member of the Committee shall expire at the end of each Annual Meeting. It shall be the duty of the Committee to procure professional papers, to pass upon their suitability for presentation, and to suggest topical subjects for discussion at the annual and semi-annual meetings. The Committee may refer any paper presented to the Society to a person or persons, especially qualified by theoretical knowledge or practical experience, for their suggestions or opinions as to the suitability of the paper for presentation. Papers from non-members shall not be accepted except by unanimous vote of the Committee.
>
> The Committee shall arrange the program, and shall have general charge of the entertainments to be provided for the members and guests for the above meetings. It shall prohibit the distribution or exhibition at the headquarters or at the places of the above meetings of all advertising circulars, pamphlets or samples of commercial apparatus or machinery. At the end of each fiscal year, the Committee shall deliver to the Secretary for presentation to the Council, a detailed report of its work.

Voted: To adopt the following new Rule 4:

> Papers accepted by the Committee on Meetings shall be classified as follows:

> *a* Papers valuable for record, but not suitable for presentation at a meeting, which will be referred to the Publication Committee with the recommendations of the Committee on Meetings.
>
> *b* Papers requiring either advance publication or printing and distribution in pamphlet form, either in full or in abstract for discussion at a meeting.
>
> Papers of this class the Committee on Meetings may either turn over at once to the Publication Committee for advance publication in The Journal if approved by that Committee; or it may have printed in pamphlet form a sufficient number of copies for distribution at a meeting, for mailing in advance to those who may discuss the paper and to others who may desire copies because of publication of the title or an advance abstract of the paper in The Journal.
>
> *c* Papers which require discussion at a meeting to determine their value and general interest.
>
> Papers of this class may be accepted by the Committee on Meetings, but should not be put in type until they have been read and discussed.
>
> The Committee on Meetings may in its discretion select papers for the annual or semi-annual meetings which have already been presented and discussed before local meetings of the Society.
>
> A member may by letter signify his intention to discuss any of the papers, and unless otherwise directed by the Presiding Officer priority in debate shall be given in the order of the receipt by the Secretary of such notification.

The Committee on Constitution and By-Laws presented amendments to By-Laws 13 and 29, which on motion were approved, due notice having been given:

> B 13 The voting for the election of officers shall close at ten o'clock in the forenoon on the first Tuesday in December in each year: The Tellers shall not receive any ballot after the stated time for the closure of the voting. The tellers of Election shall first open and destroy the outer envelopes and shall then open the inner ones, canvass the ballots and certify the result to the President or Presiding Officer at the first session of the current meeting of the Society. The Presiding Officer shall then announce the candidates having the greatest number of votes for their respective offices, and declare them elected for the ensuing year.

> B 29 A Nonimating Committee of five members, not members of the Council, shall be appointed by the President within three months after he assumes office. It shall be the duty of this Committee to send to the Secretary, on or before September 15, the names of consenting nominees for the elective offices next falling vacant under the Constitution. Upon the request of any member or Associate, the Secretary shall furnish to the applicant the names of such nominees. The names of the nominees proposed by the Committee shall be published in the next issue of The Journal.

Voted: That Dr. Alex. Humphreys be appointed to represent this Society on the Board of Trustees of the United Engineering Society to serve for a term of three years, filling the unexpired term of the late Charles Wallace Hunt.

H. G. Stott, Chairman of the Committee appointed to coöperate with the National Association of Master Steam and Hot Water Fitters in recommendation of extra heavy steam pipe flanges and fittings, presented a report of action taken in the joint committee, with the schedule of standards.

Voted: That the report be accepted with thanks and be referred to the Committee on Meetings with the recommendation that it be presented at the Spring Meeting.

The President presented a report of action taken by a committee of engineers concerning the pending legislation in Albany advocating the licensing of engineers.

Voted: To approve the appointment by the President of Honorary Vice-Presidents James Christie, J. Sellers Bancroft, J. M. Birkinbine, George W. Melville, James M. Dodge, A. C. Jackson, to attend the annual meeting of the American Academy of Political and Social Science in Philadelphia April 7 and 8.

Voted: To approve the appointment of Honorary Vice-Presidents F. R. Hutton and F. B. Gilbreth, to attend a meeting of the Welfare Section of the National Civic Federation on April 6.

Voted: To confirm approval of the action of the Executive Committee with respect to applicants for membership as approved by the Membership Committee for the Spring Ballot.

Voted: To accept the resignations of T. S. Hamilton, Louisville, Ky., E. S. Barlow, New York, W. M. Peckham, Troy, N. Y.

NECROLOGY

CHARLES WALLACE HUNT

Charles Wallace Hunt, Past-President of The American Society of Mechanical Engineers and of the United Engineering Society, was called to his rest on March 27, 1911, filling to the full his allotted three score and ten years.

He was born at Candor, Tioga County, New York, on October 13, 1841. His early scientific education was begun at Cortland Academy, Homer, New York, but during his life he never ceased to be a student. During the Civil War, Secretary Stanton assigned to him the duty, for which his kindly nature and sound judgment admirably fitted him, of looking after the welfare of the thousands of negroes who flocked into the Union lines from the Southern States. He taught them how to take care of themselves by putting them at work in the mills furnishing supplies for the Government.

Returning from his services to the Government, about 1868, he began his business career on Staten Island, New York, in the storing and handling of coal. It was here that his engineering career began. He realized how slow and expensive the process of handling coal then was and set about to improve it. The result was the development of his automatic railroad, by which the coal was lifted from barges and carried back on an elevated track and dumped automatically at any desired point. This system was later introduced to a large extent, notably at the large coal stations of the Calumet and Hecla mines on Lake Superior, and in many other lake and seaports in this country and abroad. The automatic railway completely solved the problem, and so perfectly that few if any improvements in this particular device have been made since. This work led to the invention of many coal-handling devices.

Later he became interested in the development of the system of chain conveyors running on wheels and having swinging buckets which always remained upright except at the points where they were dumped. This system was very largely and successfully used in many large steam power plants and locomotive coaling stations. By its use coal could be carried horizontally, or vertically, or at any angle, from any point and delivered automatically and continuously at any one of many other points; and ashes could be collected at many different points and delivered at other points by the same endless conveyor chain with buckets carried on wheels, and kept continuously in motion by an ingenious pushing device that avoided very largely the friction of the ordinary sprocket chain machines, then in common use, which dragged the coal along the bottom of a trough.

A story is told of him by one of his friendly competitors which is both characteristic of the man and vividly brings out the difference in principle of these two systems. The two men were before a committee which had to decide on the purchase of one of the two systems presented. Mr. Hunt said: "If you wished to move a cat from one corner of the room to the other with the least effort and trouble, would you catch it by the tail and drag it across against the resistance of its claws in the carpet, or would you gently lift the cat into a basket and smoothly and easily carry it across?" He got the contract and his competitor enjoyed the story.

His genial humor, coupled with his straight-forward common sense and ability to get at foundation principles, were among his most attractive characteristics.

In connection with his coal-handling machinery, Mr. Hunt was called upon to design and build many large steel structures for the storage of coal in large quantities. These included the coal stations for the United States Navy at Guantanamo, Puget Sound and Manila, as well as other large plants in South Africa, Europe and Australia.

In addition to the large plant of the C. W. Hunt Company on Staten Island, New York, of which he was President, there were plants in England and Germany for the manufacture of machinery designed by him. The development of coal-handling machinery by Mr. Hunt and his associates has reduced the cost of handling coal from about thirty to three cents per ton. He designed machinery for the rapid and economical handling of freight, a notable example being that at the Greenville terminal of the Pennsylvania Railroad.

Another direction in which Mr. Hunt showed his ingenuity and good engineering sense, was in the development of his industrial railway. He adopted a narrow gage of 21½ inches for his tracks, which were made in complete sections ready to be joined together in any desired combination with very short curves and switches and turntables enabling the tracks to be carried anywhere around shops and yards. His cars were made in a great variety of special forms to do special work in the best manner. The wheels of his cars have their flanges on the outside, contrary to the common practice, for which he claimed great advantage in reducing the resistance of the car on the track and particularly on short curves. He was probably the first to build and use electric storage battery locomotives on very narrow gage railways having very short curves. These locomotives involved special and unusual problems which he showed great ingenuity and skill in solving.

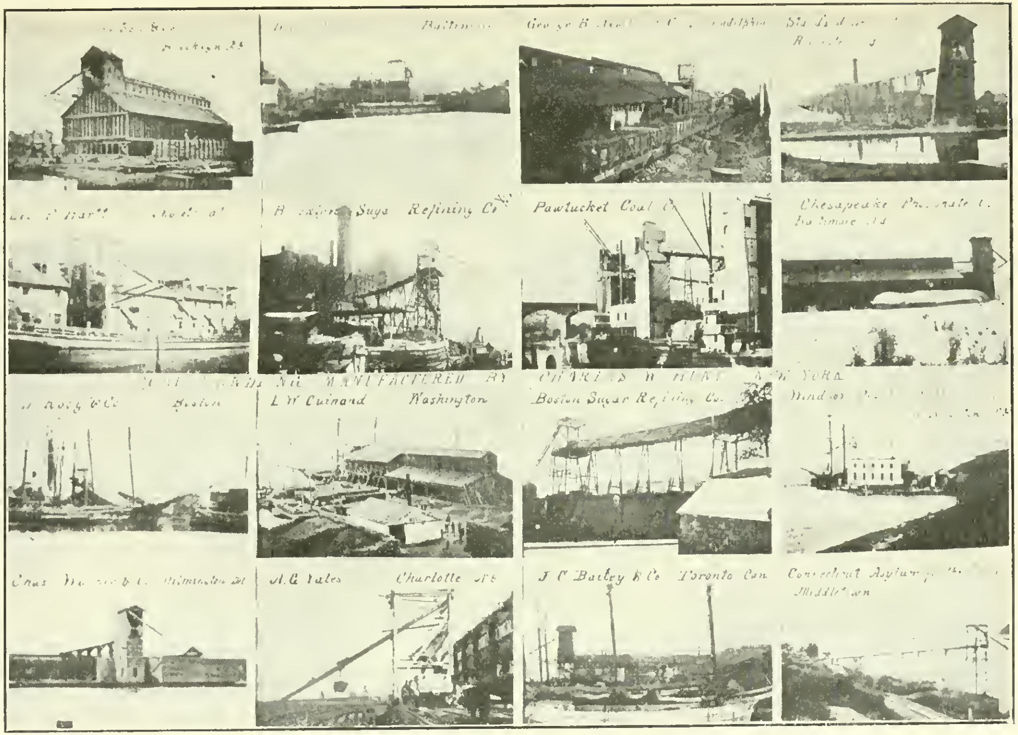
His inventive genius is represented by one hundred and forty-seven patents issued to him and three others which have been allowed.

Mr. Hunt had a deep interest in the profession of engineering and was always ready to devote his time and energy to its advancement. His private interests were always held secondary to his interests in the various Engineering Societies of which he was a member.

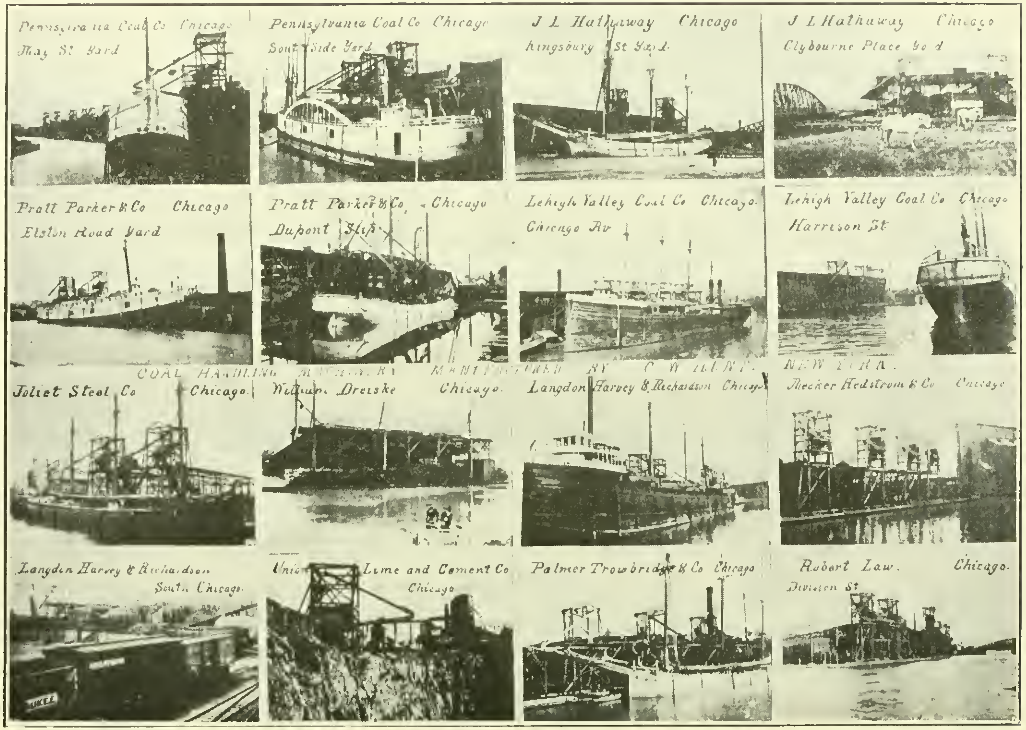
He has been a member of The American Society of Mechanical Engineers for 26 years and was elected one of its Vice-Presidents in 1892 and became its President in 1898. He has served on many of its most important committees and his devotion to the work has been manifest in all the large policies adopted by the Society. His most notable committee work was done as Chairman of the Committee appointed by the Council in 1902 to draft a new Constitution and By-Laws. The result of the assiduous work of that Committee, of which he bore the major part, was adopted by the Society in 1904 and then became its organic law. He proposed the policy, incorporated in the Constitution, of putting the various activities of the Society in charge of Standing Committees of five members each, one member retiring and one new member coming on each year, by which a large number of men, devoted to the best interests of the Society have been brought into its active management. He remained Chairman of the Committee on Constitution and By-Laws to the time of his death, and his last work for the Society was done in that Committee on February 17 last. In no place will his broad-minded yet conservative counsel be more great lymissed.

Mr. Hunt ceased to be a statutory member of the Council in 1904 but he, with other Past-Presidents, were invited by the Council to sit at its sessions as Honorary Councilors. Although not obliged to be present, he rarely missed a Council meeting when his health permitted and always gave such sound advice that the members of the Council were wont to show their sincere respect by referring to him as our "Elder Councilor."

Mr. Hunt was also a member of the American Institute of Electrical Engineers; the American Institute of Mining Engineers; the American Society for the Advancement of Science; Franklin Institute;



Some of the Work of Past-President Charles Wallace Hunt
The photographs reproduced on this and the opposite page were submitted by Mr. Hunt with his application for membership in 1885.


Pennsylvania Coal Co Chicago
May St Yard
Pennsylvania Coal Co Chicago
South Side Yard
J L Hathaway Chicago
Kingsbury St Yard
J L Hathaway Chicago
Clybourne Place Yard
Pratt Parker & Co Chicago
Elston Road Yard
Pratt Parker & Co Chicago
Dupont Slip
Lehigh Valley Coal Co Chicago.
Chicago Av
Lehigh Valley Coal Co Chicago
Harrison St
COAL HANDLING MACHINERY MANUFACTURED BY C W HUNT NEW YORK.
Joliet Steel Co Chicago.
William Dreiske Chicago.
Langdon Harvey & Richardson Chicago
Mecker Hedstrom & Co Chicago
Langdon Harvey & Richardson
South Chicago.
Union Lime and Cement Co
Chicago
Palmer Trowbridge & Co Chicago
Robert Law. Chicago.
Division St

Coal and Ore Handling Machinery Designed by Mr. Hunt

He was a pioneer in this field, all of the work shown on these pages having been done prior to election to membership in 1885.

New York Electrical Society; Inventor's Guild; New York Chamber of Commerce; National Geographical Society; Staten Island Association of Arts and Sciences; Staten Island Chamber of Commerce; The Engineers' Club; The Railway Club; The Hardware Club; and The Machinery Club. He was President of the Richmond County Savings Bank.

When Mr. Andrew Carnegie made his notable deed of gift in 1903 to be devoted to a building for the Engineering Societies, Mr.Hunt was promptly chosen as a member to represent The American Society of Mechanical Engineers on the organization committee, and later of the building committee, and finally of the Board of Trustees of the United Engineering Societies. He continued in office during two terms under the principle, which he himself recommended, that no trustee should be immediately eligible at the close of a second term. After a year had elapsed however, he was re-elected to serve in the position which he had so conspicuously adorned. He was at the beginning of his third term when death overtook him. His influence in the Board was conservative, yet progressive. It was his recommendation that no decision of the Building Committee should ever be carried out until the entire Board was unanimous respecting it. That was largely responsible for many well-balanced decisions respecting details of the building and its consequent satisfaction to all parties. Up to the very beginning of his last illness he was active and suggestive respecting certain propositions looking to the development of the library and of an enlargement of its scope and usefulness.

Mr. Hunt served also on many other committees representative of the Society. About a dozen years ago he served as a representative of the Society in formulating a revision of the Building Code of the City of New York to take care of the changes introduced by steel construction and the tall cellular building. He served also on the committee to install the Thurston memorial tablet and was a member of the John Fritz Medal Board. He also served on a committee to write the history of the Society. From time to time he contributed from his experience several valuable papers to the Society.

In his presidential address in December 1898, at the Annual Meeting of that year, Mr. Hunt took as his title, The Engineer, and in that paper, drawing most largely perhaps upon his own philosophy of life, he made this statement, doubtless also the product of his own experience: "The life of an engineer has a full measure of the labors, the trials, the discomforts and the disappointments which are found in this as in every other walk of life, but—it has also the successes which come from well directed labors. It is not, however, either the useful work in itself, or what are called the successes of life, which bring happiness. It is a man's ideals which make him happy. . . . Cheerfully can he enter upon his daily task with the consciousness that his application of these discoveries is of real service in lightening the burdens of our life, as well as elevating and ennobling his fellow men." Such was the story of Mr. Hunt's life and such were his achievements.

Col. E. D. Meier, President of the Society; Prof. F. R. Hutton, Past-President and Honorary Secretary; Henry R. Towne, Past-President; Jesse M. Smith, Past-President; Alex. C. Humphreys, Vice-President; Henry G. Stott, Manager; Charles Kirchhoff, John W. Lieb, Jr., Alfred Noble, W. H. Fletcher, Members; and Calvin W. Rice, Secretary, were appointed Honorary Vice-Presidents to attend the funeral and represent The American Society of Mechanical Engineers. This was held in the Church of the Ascension at West New Brighton, on Thursday, March 30. The body of Mr. Hunt was laid at rest in the beautiful cemetery at New Dorp, Staten Island, New York.

EVERETT HANSON WHITE

Everett Hanson White was born May 26, 1872 at Barre, Mass. He received his early education in the public schools of his native town and in 1888 entered the employ of the Putnam Tool Company, Fitchburg, Mass., taking three years' special training in the shop. He became connected with the Houston Electric Company and later accepted a position with the Wire Goods Company of Worcester, Mass., and with Plummer, Ham and Richardson of the same place. In 1899 he entered the employ of the Locomobile Company of America as draftsman, and at the end of eight months was promoted to the position of chief draftsman at the Bridgeport, Conn. factory where he also had charge of the experimental department. He designed their 1902 Touring Carriages and Worcester engine which developed 7½ h.p. and weighed but 45 lb. In 1903 Mr. White accepted a position with the Eaton, Cole and Burnham Company, of Bridgeport, later controlled by the Crane Valve Company of Chicago, and was then made consulting engineer of the company. In 1905 he entered Sheffield Scientific School of Yale University and completed the four years' course in one year. He died January 12, 1911, at Bridgeport, Conn.

FREDERICK L. HART

Frederick L. Hart died March 23, 1911, at Jamaica, N. Y. He was born July 3, 1861, in Brooklyn, N. Y., and was a graduate of the Polytechnic Institute of that city. He served his apprenticeship of a year and a half at the Columbian Iron Works of Brooklyn and three and a half years at the Wright Steam Engine Works of Newburgh, N. Y. His professional work included the erection of an ochre mill for the Franco-American Mining and Ochre Company of Brooklyn, and the installation and operation of an electric plant for the New York and Brooklyn Bridge. He was connected for a period of four years with the Third Avenue Railroad Company of New York as chief engineer and later in the same capacity with the Tenth Avenue and 125th Street Cable Railroads resigning later to become engineer in charge of the Broadway Railway Company. Here he remained for two years and then became general manager of the Baltimore City Passenger Railway Company a position which he held for six years. Subsequent to this he was associated with the Washington Railway and Electric Company and the Thomas Bashor Company, contracting engineers of Baltimore.

GEORGE B. CALDWELL

George B. Caldwell was born in Lowell, Mass., April 11, 1863. He received his early education in the public schools of Lowell and at the age of seventeen he became an apprentice of the Lawrence Manufacturing Company of Lowell, serving his time in their shops and drafting rooms. At the end of his apprenticeship he remained with the same company as assistant to the master mechanic until 1899, when he accepted the position of master mechanic of the Washington Mills Company, Lawrence, Mass., where for four years he was in charge of their drafting rooms as well as their construction and repair work. In 1893 he entered the employ of Westinghouse, Church, Kerr and Company and retained his connection with this firm until the time of his death, March 31, 1911. During this period he was in responsible charge of designing and constructing many works of engineering interest, among which may be mentioned the mechanical and electrical features of the South Terminal Station, Boston, Mass.; the Pittsburg terminal of the P. & L. E. R. R.; the railroad shops of the P. & L. E. R. R. at McKees Rocks; the construction of the Kingsbridge Power Station of the Third Avenue R. R. He also supervised the design and installation of the Long Island Railroad Company's electrification, including the large power house at Long Island City. His last work was the design and construction of the mechanical and electrical features of the Pennsylvania Terminal Station in New York City, which he was obliged to relinquish just before it was completed. Mr. Caldwell was also a member of the American Society of Civil Engineers. He was a man of unswerving integrity and of great energy, inspiring perfect confidence and respect in all those with whom he dealt.

ARNDT L. HAMMARBERG

Arndt L. Hammarberg was born October 4, 1862, in Gothenberg, Sweden, and received his technical education at the Chalmers Technical Institute, Gothenberg, from which he was graduated in 1881. His early experience was obtained with the Bergsund Shipbuilding Company, at Stockholm, and as designer and draftsman with the Donnarvest Iron and Steel Works. In 1889 he came to the United States to take a position with the Illinois Steel Company, remaining until 1891 when he entered the employ of the Homestead Steel Works. In the following year he was placed in charge of the rolling mill construction of the Morgan Construction Company, Worcester, Mass., and between the years 1895 to 1898 was successively connected with Julian Kennedy and with Mackintosh, Hemphill & Company, Pittsburgh, Pa., and with the Lloyd Booth Company of Youngstown, Ohio. In 1898 he entered the employ of the Wellman-Seaver Engineering Company, at Cleveland, as chief engineer; leaving there to become chief engineer in 1900 of the Ensley Steel Works, and in 1902 of the Youngstown Sheet and Tube Company. In 1907 he returned to Sweden, and until the time of his death on February 7, 1911, was employed as chief engineer at the Bergsund Shipbuilding Company at Falun.

DWIGHT B. WILSON

Col. Dwight B. Wilson, who died at Denver, Colo., on March 7, 1911, was born at Lewiston, Me., on May 5, 1848, and received his techincal education at the Holmes Commercial School in Boston, Mass. During the Civil War he served under General B. F. Butler as a private. In 1880 he removed to Colorado where he engaged in construction work, and in 1895 was appointed commissioner of highways in Denver. In 1899 he entered the employ of the Denver City Tramway Company, as superintendent of power. One of his notable achievements during the twelve years of his service was the erection of a new power station costing $1,500,000.

Mr. Wilson was a member of the National Association of Stationary Engineers.

THE PROCESS OF ASSEMBLING A SMALL AND INTRICATE MACHINE

By Halcolm Ellis

ABSTRACT OF PAPER

The Ellis adding-typewriter is a combination typewriter and adding machine composed of about 3400 pieces. To secure rapid and economical assembling of such a large number of parts a very elaborate system is necessary. Not only is the machine designed to be assembled in sections, but some of these sections are divided into sub-sections, small groups of assembled parts, assembled parts and individual pieces, all of which are numbered. All the parts are produced by means of carefully made dies, jigs and fixtures so as to be interchangeable without special fitting. During the manufacture of the various parts a record is kept of the successive operations on each one, so that it is possible to tell at a glance what stage each piece has reached at a given time. The sheet on which these records are kept is called the operation docket. When a stock of parts has been produced, each section and sub-section is assembled independently by means of assembling charts and photographs of the parts required for each section. Numerous illustrations show the method employed and various stages of the work from the production of the parts to the completed machine.

THE PROCESS OF ASSEMBLING A SMALL AND INTRICATE MACHINE

By Halcolm Ellis,[1] Newark, N. J.

Non-Member

The machine here described is little larger than an ordinary typewriter, but the number of parts is greater and the mechanisms included within it are much more complicated. It is known as the Ellis Adding-Typewriter, and is composed of about 3400 pieces assembled in various ways. Before taking up the question of the assembling, it may be well to give a brief description of the machine itself and what it will do.

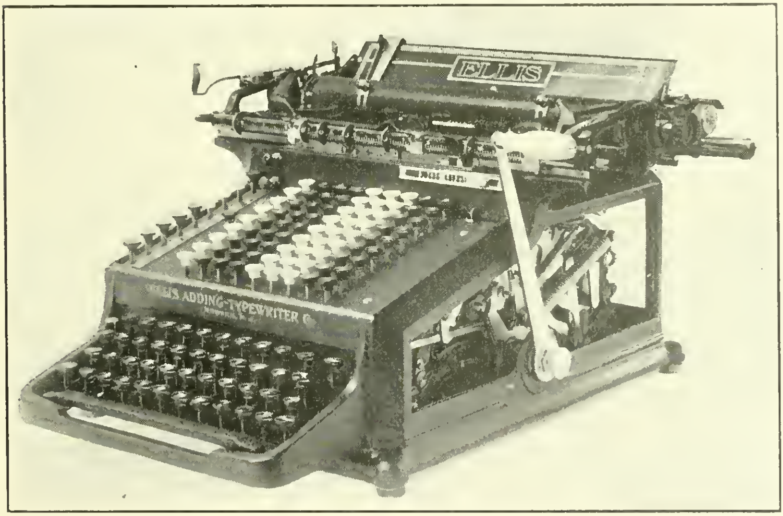


Fig. 1 The Ellis Adding-Typewriter with Glass Sides Removed

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[1] General Manager, Ellis Adding-Typewriter Co., Newark, N. J.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

2 The machine (Fig. 1) is primarily a typewriter, and includes all of the elements which go to make up any other standard form of visible printing typewriter. It is provided with a universal keyboard having 42 keys, shift-keys for capitals and signals, tabulating devices and keys for operating them, automatic ribbon movement and ribbon reverse, a device for using a bi-chrome ribbon, thereby enabling the operator to do the printing in two different colors, and a large number of little mechanical conveniences for helping the operator in a speedy execution of his work.

3 Also incorporated in the machine is a complete adding and listing machine, provided with a keyboard containing 81 numeral keys for the setting up of numbers to be added and nine operation keys for setting the machine to perform the different operations of calculation for which it is designed. The adding mechanism controls its own printing device for the printing of numbers, and all totals and sub-totals or other results of arithmetical computations are printed automatically on this machine. The typewriting type and the adding type print on the same horizontal line, and the printing from both is entirely visible.

DESIGNING THE MACHINE TO SECURE RAPID ASSEMBLY

4 The need of a very definite system in the designing of a machine of this character, in order that it may be assembled at all, is evident, and it is also clear that it would be a commercial impossibility to assemble it as a whole, i.e., if each machine were to be built up, piece by piece, by the same man. The solution of the assembling problem lay in the sub-division of assembling and this was accomplished by dividing the machine into sections. These sections in turn were divided into sub-sections, small groups of assembled parts, assembled parts and individual pieces. The machine as a whole was divided into 16 sections, and each section was given a letter; then in order to keep the symbol numbers in order the individual parts were numbered according to the following schedule.

SECTIONS OF ELLIS ADDING-TYPEWRITER

A = Accumulator Mechanism.
B = Base, Frames, Case, Spring Barrel, Carriage Ways.
C = Carriage.
D = Left-hand Operating Parts, Governor.
E = Escapement.

F = Tabulating Mechanism and Bell, and Line Lock.
H = Holder for Paper Roll.
I = Ink Mechanism.
K = Keyboard and Parts for Adding Mechanism.
L = Left-hand Controlling Parts.
O = Operating Handle, Shafts and Parts connected therewith.
P = Printing Mechanism.
R = Reducer or Concentrator Shaft and Parts.
S = Shifting Part of Carriage.
T = Typewriter Parts.

SUB-DIVISION OF EACH SECTION

0–9	Shafts.
10–29	Studs, Pins and Screws.
30–44	Collars (screw machine parts having holes).
45–49	Castings.
50–74	Punched Parts.
75–79	Drop Forgings.
80–89	Springs.
90–99	Miscellaneous parts not in above classification.

A general system was also required in the designing of the machine itself in addition to the numbering of the individual parts. Iron castings were determined upon to form the bases and the main frames on which the other parts are mounted. Most of the latter are made of sheet-metal punchings, combined with and suspended on screw machine parts, and so mounted on the iron castings. Each section of the machine was designed to be, so far as possible, a complete working unit, interchangeable on different machines. Each section was arranged to have the fewest possible points of connection to the operating means, since it is easier to obtain synchronism where the motive power is derived from a single source rather than from a plurality of sources.

5 Next there was the grouping of members and parts for similar functions. This grouping is of twofold advantage. In some cases it is of material benefit to the operator of the machine, and in other cases of benefit to the assembler in putting the machine together. The necessity for this grouping and segregation of parts is almost as great in a machine of this kind as in a department store, where it is easy to imagine the confusion that would result if the store were maintained and all the departments abolished. In consequence of this grouping the typewriter keys are entirely separate from the adding machine keys, the operation keys of the adding machine are in a single column on the left-hand side of the adding machine keyboard, the adding

machine tabulating key on the adding machine keyboard, and the typewriter tabulating key is with the typewriter keys.

6 Regarding the inside of the machine it can be said that all shafts which have a constant motion when the handle of the adding machine is operated are controlled by the mechanism on the right-hand side of the machine, while shafts which have an irregular movement in relation to the handle movement are controlled by the mechanism on the left-hand side of the machine.

7 The adding machine itself is mounted on two vertical cast-iron side frames extending longitudinally of the machine. The parts between the two frames are primarily for executing the work of calculation and printing, while the parts on the outside of the two frames are for determining and directing the operation of the parts between the frames.

8 These facts may not seem to have much bearing on the problem of assembling the machine itself, but they are of extreme importance in this connection. By knowing the location of the parts which do the work the assembler is assisted in inspecting the work as he goes along and is instantly enabled to locate troubles and faults. If the machine were designed without this separation of functions it would be very difficult indeed to determine just what the trouble might be in many cases where the parts are out of sight.

9 There are many other limitations in the designing of a machine of this character, such as the convenience of the machine to the operator, so as to enable him to attain speed in the execution of his work; the character of the parts and the method of producing them, such as punchings, screw machine parts, castings, etc., and the means of machining and finishing these parts so that they can be used interchangeably. Esthetic considerations must be applied to determine the size, form, color and finish of surface, ornamentation, etc., of the machine as a whole. Also, the assembling and operation requirements call for consideration in the design. These include the limitations of the materials in strength, lightness, hardness, elasticity, etc.; the allowance of clearance to correct errors due to distortion; the spring of parts; the effect of rebound and means of overcoming it; irregularities in castings and in the machining of parts; changes due to variation in temperature, etc. These are some of the points which, if carefully considered by the designer, help somewhat in the ultimate assembling of the machine, and if neglected arise spectre-like to worry the maker afterwards.

THE PRODUCTION OF PARTS

10 System in designing is the first step in the assembling; the second step is the accurate production of individual parts and the accurate assembling of small groups of these parts. In general, the parts in this machine are of three kinds: punchings, screw machine parts, and castings. The latter have various machine operations on them.

11 The punchings of which this machine is mainly composed, are all produced from dies similar to that shown in Fig. 2, and

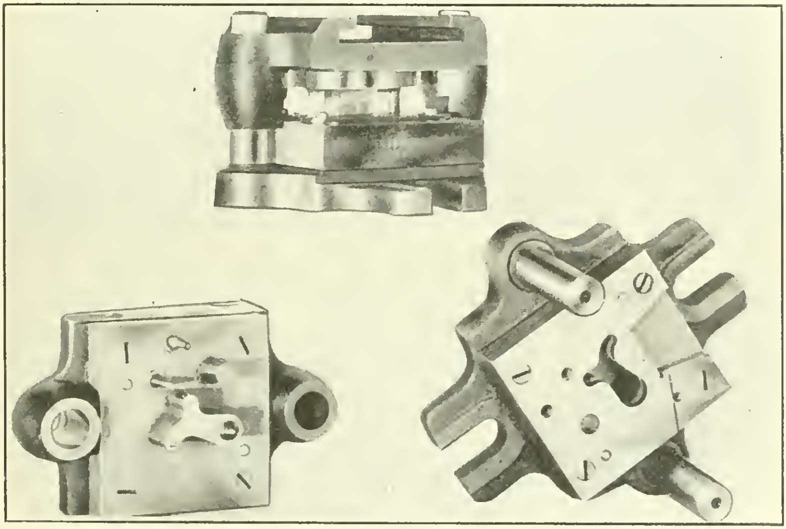


Fig. 2 Typical Blanking Die

are, properly speaking, sub-press dies. The work, however, is not returned into the stock as in many forms of sub-press work, but passes through the orifice in the bottom of the lower bolster. Over 400 dies of this general character are required, and the component parts were made of standard sizes and in considerable quantities. The bolsters and caps were planed or milled in good-sized lots and then drilled and reamed for the guide posts, which were ground to size in lots. The stock parts for the dies, strippers and punch holders were also made up in quantities of standard size, carefully ground top and bottom, and the die stock was labeled with the brand of steel and blued for the layout. There were, of course, a number of standard sizes of stock sub-presses. The punch stock was not made in standard sizes but was cut special in each case.

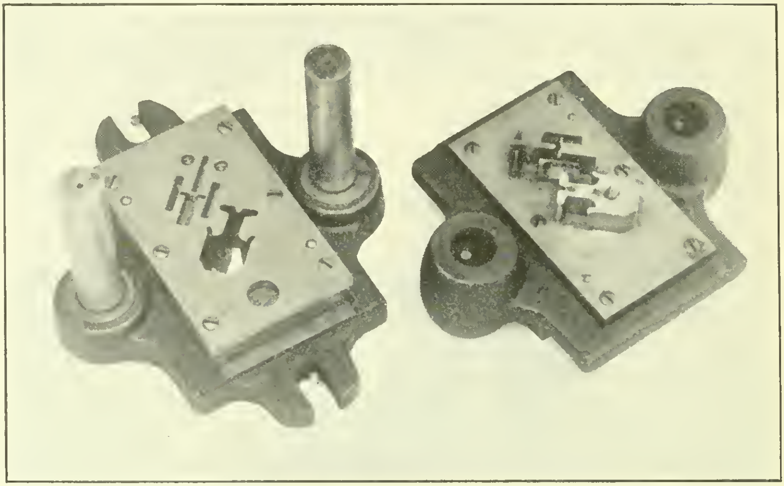


Fig. 3 Two-Step Progressive Blanking Die for 50 I

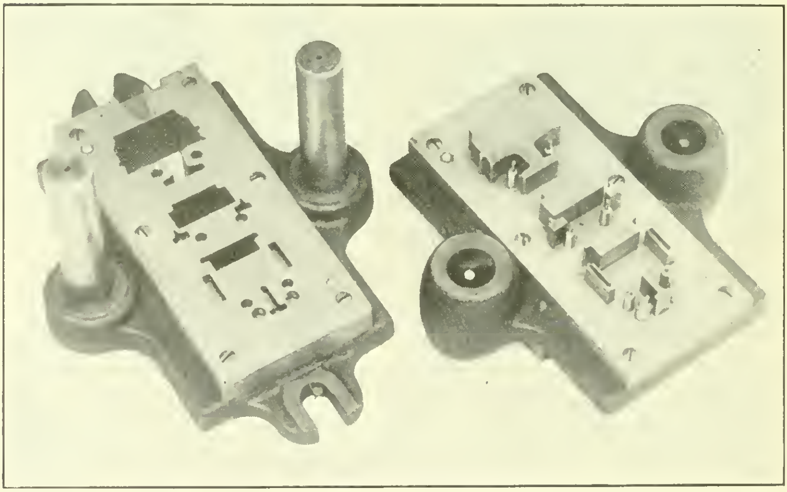


Fig. 4 Three-Step Progressive Blanking Die for 51 I

12 While the great majority of punching dies are of this simple kind, there are also many others much more complicated, as shown in

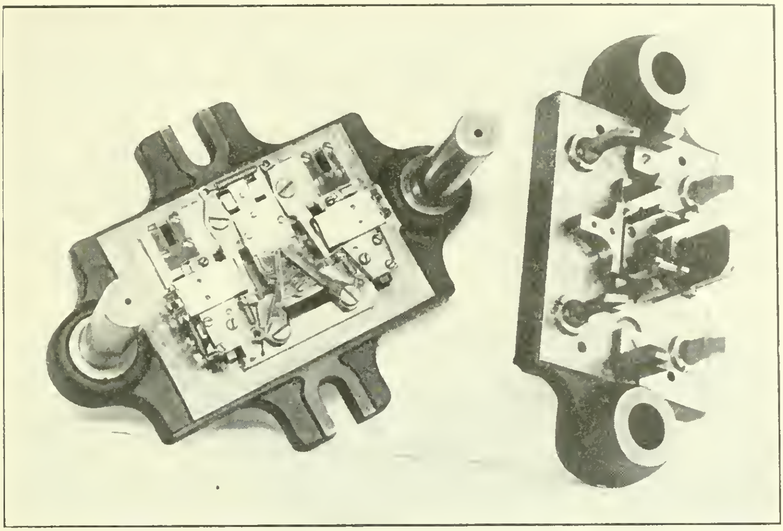


Fig. 5 Forming Die for 50 I

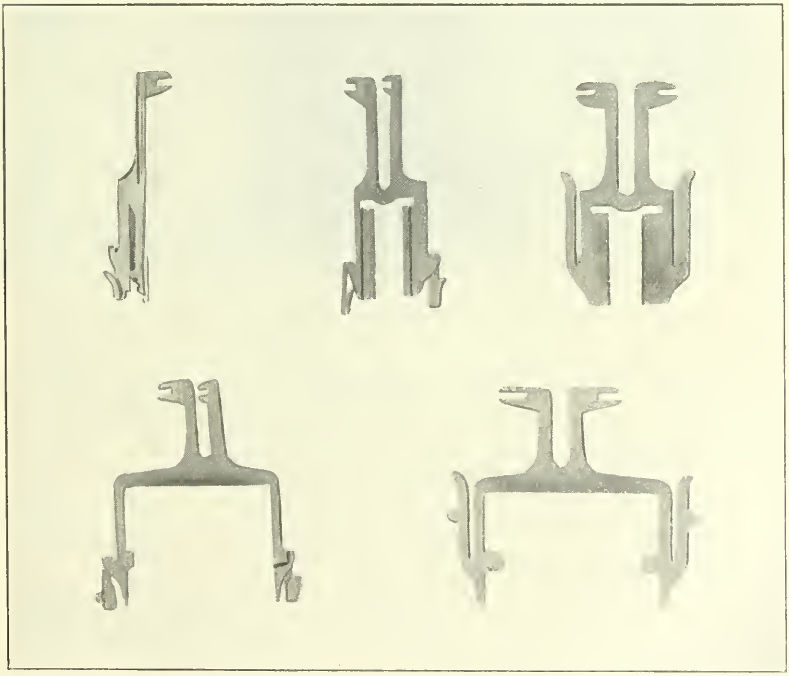


Fig. 6 Ribbon Vibrators 51 I and 50 I

Fig. 3, which is a two-step progressive blanking die, and in Fig. 4, which is a three-step progressive blanking die.

13 Bending, drawing and forming dies are mounted, in most cases, in the same type of sub-press and vary in character from the most simple to quite complicated ones. One of the more complicated dies is shown in Fig. 5, and the piece it produces, in the flat and finished shape, in Fig. 6. The flat blanks being produced in the dies shown in Figs. 3 and 4 are the ribbon vibrators, which are entirely bent to the finished shape by one operation of the bending die.

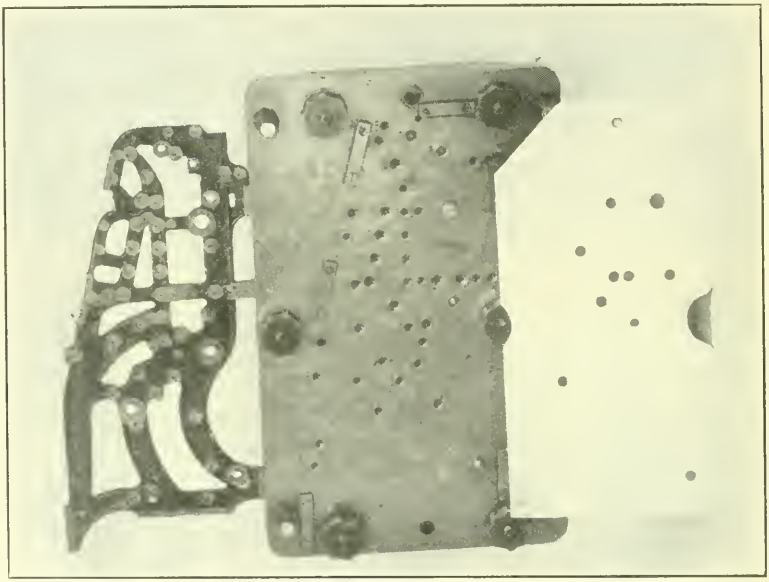


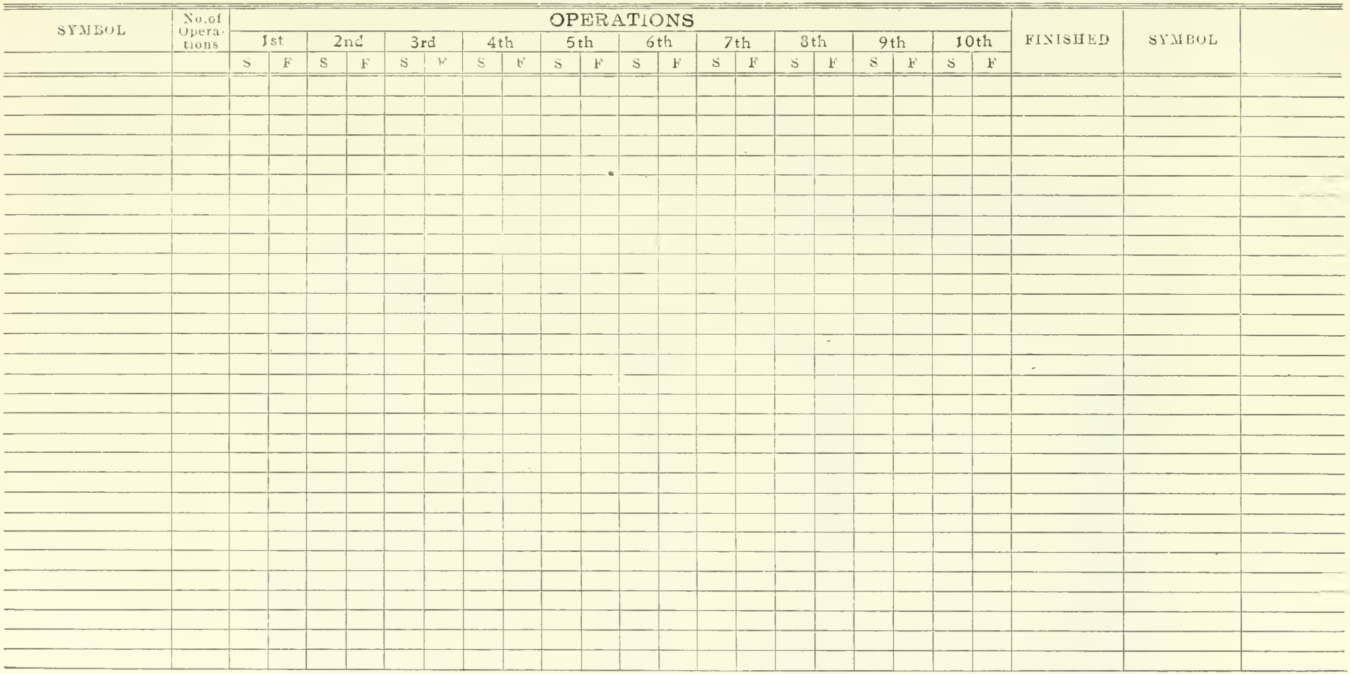
Fig. 7 Left Side Frame B47, Drill Jig and Mask Plate

14 The making of the dies, together with the other tools for this machine, required the services of about 40 toolmakers for a period of over three years.

15 A few of the screw machine parts are finished on turret forming machines, but most of them are made on Brown and Sharpe automatic screw machines, the processes and tools being in no way different from those generally employed.

16 The castings are the most complicated pieces in the machine, but an effort has been made to keep the machine operations on them as simple and straight as possible. As an illustration, the side frames

Lot. No. .... For .... Machines



SYMBOL	No. of Operations	OPERATIONS																				FINISHED	SYMBOL	
		1st		2nd		3rd		4th		5th		6th		7th		8th		9th		10th				
		S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F	S	F			

FIG. 8 OPERATION DOCKET

The sheet actually used provides for twenty operations.

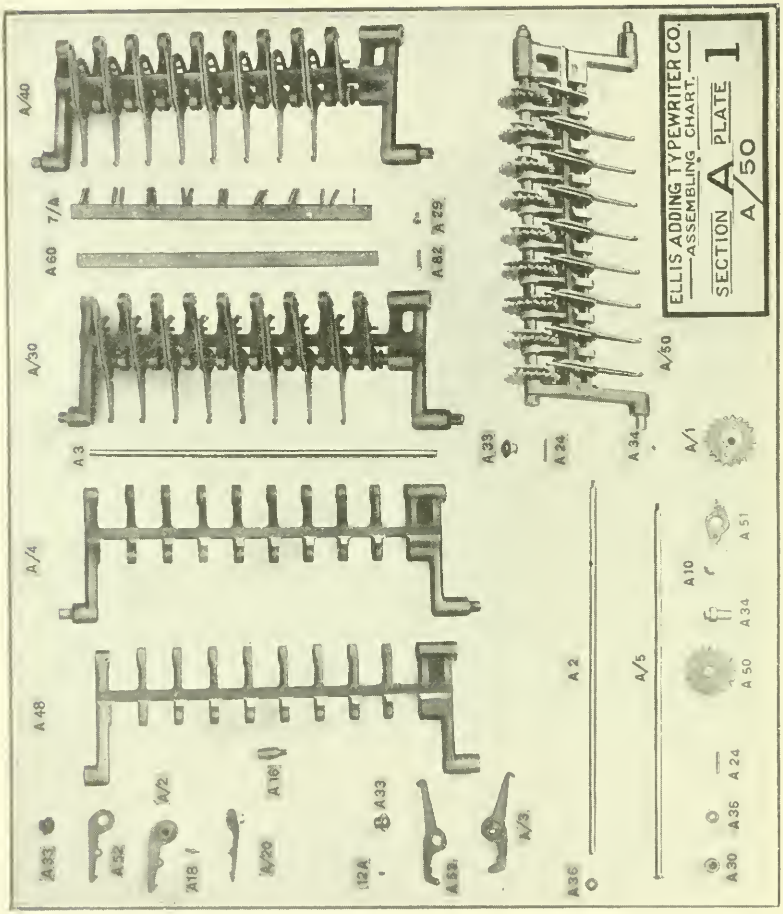


Fig. 9 Assembling Chart for Sub-Section A/50

B 46 and B 47 (see Fig. 7) are of uniform thickness through all flanges and bosses. These castings have an allowance of only 1 mm. in thickness for finish on the two sides. They are straightened in a press, after being heated, and are then japanned. Following this they are ground to size on Pratt and Whitney vertical surface grinding machines at the rate of about five minutes per pair. No difficulty is experienced in bringing the two sides of these frames perfectly flat and parallel, with a variation in thickness not over 0.01 mm. After the frames are ground, they are drilled and milled. The left-hand frame, B 47, has 61 holes through it, requiring over 200 operations. The master plate from which the drill jig was made required about 70 days' time of the most expert workmen. The resultant plate contains 66 holes true to drawing within 0.01 mm. As an illustration of the effect of this kind of work on a man, it might be mentioned that after about 30 days' work it was discovered that the workman had made a mistake in his calculations which put about 20 of the holes 0.1 mm. wrong, and the discovery, made by the man himself, so unnerved him that he broke down and wept and had to stop work for the day to recover himself.

17 Stock records of the manufactured parts of this machine are kept on typical card forms adapted to the peculiar requirements of this machine. The operation card, perpetual inventory, and stock order forms are too well known to be shown; but the form called the docket (Fig. 8), which shows the progress of the work on every piece during the progress of a lot of machines, may be of interest. By turning over the pages of this docket, it can be seen at a glance what work has been done and what remains to be done on every individual piece composing the machine; how long it has taken to do the work; and, by referring to back entries, how long it will take to finish the work. This form is much more visible than any card index system, and is correspondingly more useful to the foremen and superintendents.

ASSEMBLING THE SECTIONS OF THE MACHINE

18 The assembling of the machines is first done by building up what are known as sections, after which the sections are connected to form a complete machine. The growth of a single section will be illustrated by showing how the parts in the A section come together. This section is located at the rear of the machine. It consists of two entirely separate and independent adding mechanisms

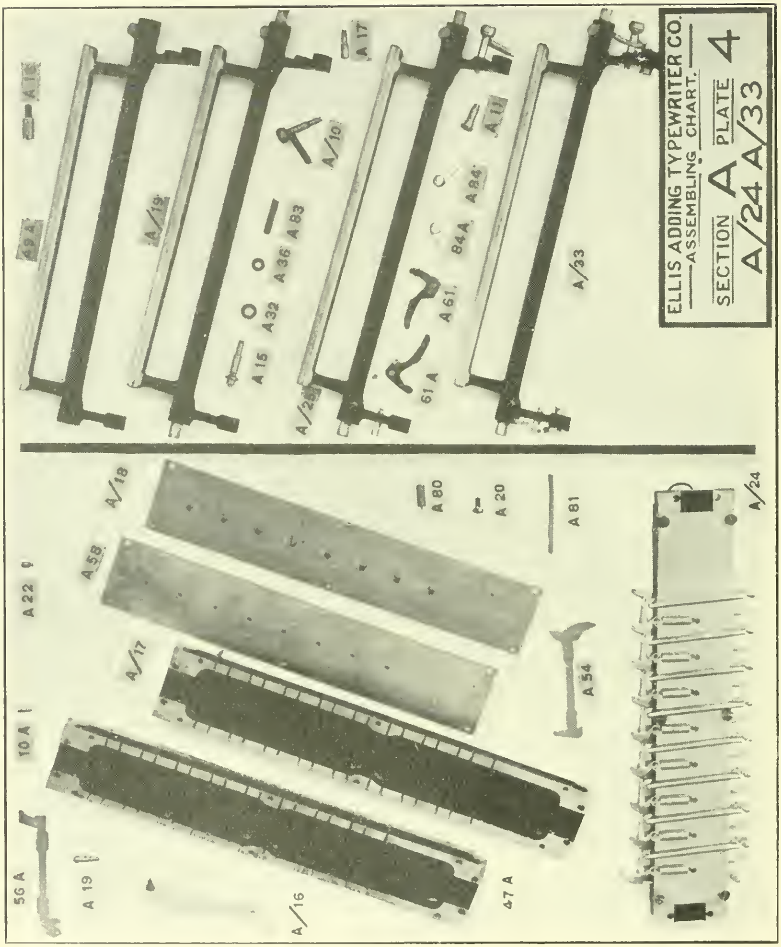
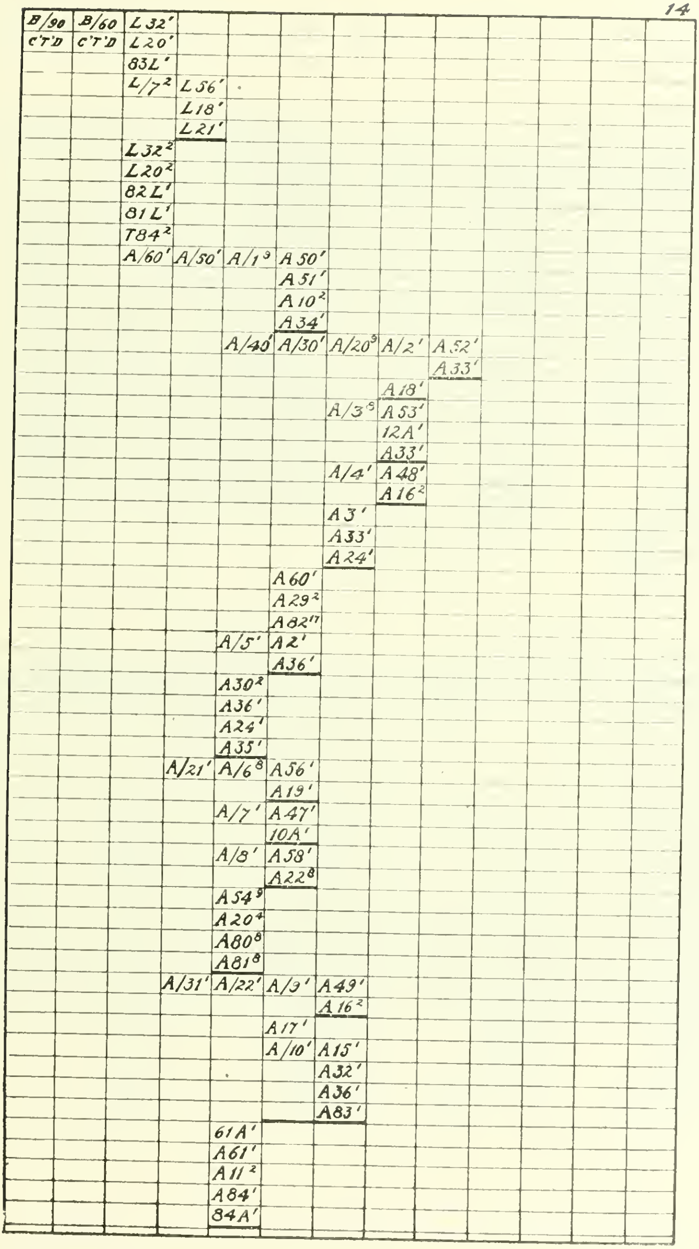


Fig. 10 Assembling Chart for Sub-Sections A/24 and A/33



14

B/90	B/60	L32'										
C'T'D	C'T'D	L20'										
		83L'										
		L/7^{2}	L56'									
			L18'									
			L21'									
		L32^{2}										
		L20^{2}										
		82L'										
		81L'										
		T84^{2}										
		A/60'	A/50'	A/1^{9}	A50'							
					A51'							
					A10^{2}							
					A34'							
				A/40'	A/30'	A/20^{9}	A/2'	A52'				
								A33'				
							A18'					
						A/3^{5}	A53'					
							12A'					
							A33'					
						A/4'	A48'					
							A16^{2}					
						A3'						
						A33'						
						A24'						
					A60'							
					A29^{2}							
					A82^{17}							
				A/5'	A2'							
					A36'							
				A30^{2}								
				A36'								
				A24'								
				A35'								
			A/21'	A/6^{8}	A56'							
					A19'							
				A/7'	A47'							
					10A'							
				A/8'	A58'							
					A22^{8}							
				A54^{9}								
				A20^{4}								
				A80^{8}								
				A81^{8}								
			A/31'	A/22'	A/9'	A49'						
						A16^{2}						
					A17'							
					A/10'	A15'						
						A32'						
						A36'						
						A83'						
				61A'								
				A61'								
				A11^{2}								
				A84'								
				84A'								

FIG. 11 TYPICAL SHEET FROM ASSEMBLING CHART

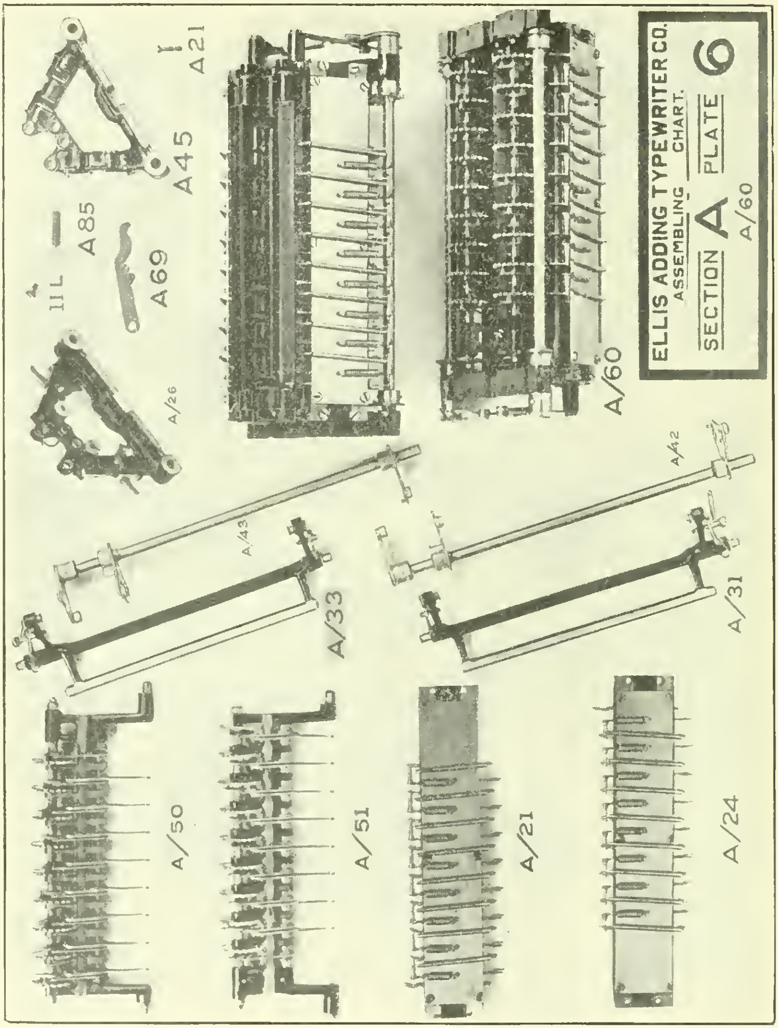


Fig. 12 Assembling Chart for Sub-Section A/60

mounted in a single frame, each being controlled by a single connecting bar from the operating mechanism of the machine, as shown in Fig. 1. The individual parts that compose section A are assembled as

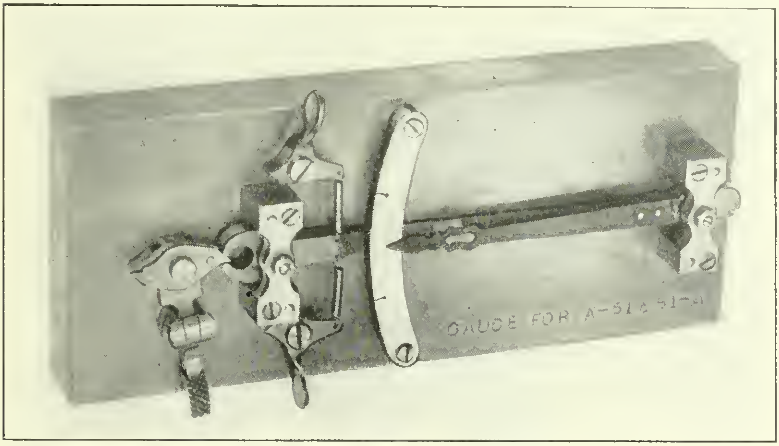


Fig. 13 Test Gage for A 51 and 51 A

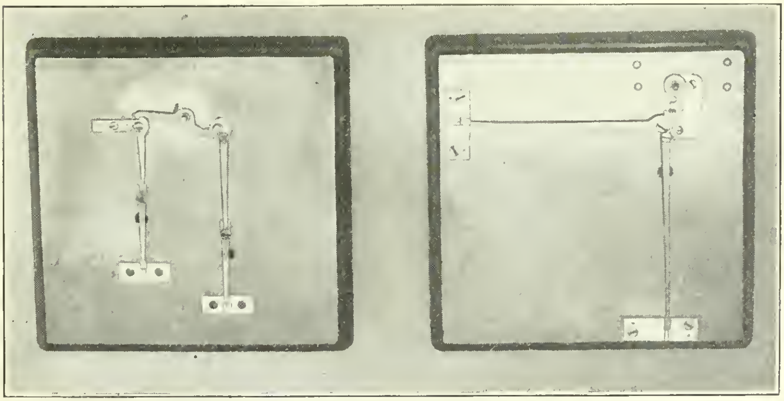


Fig. 14 Typical Test Gages

shown in Fig. 9. Here a series of parts are shown in progressive steps, from the original machine pieces up to sub-section A/50.

19 A 33 and A 52 combine to make A/2, to which is added A 18, making A/20. In the same way 12 A, A 33 and A 53 are assembled, making A/3. Two screws, A 16, are inserted in the ends of A 48, mak-

ing A/4. The shaft A 3 is inserted through a series of holes in A/4, and as it is inserted eight pieces A/3 and nine pieces A /20 are strung upon it, making A/30. Next a perforated strip A 60 has a series of springs A 82 connected to it, making 7/A, which is mounted on A 30

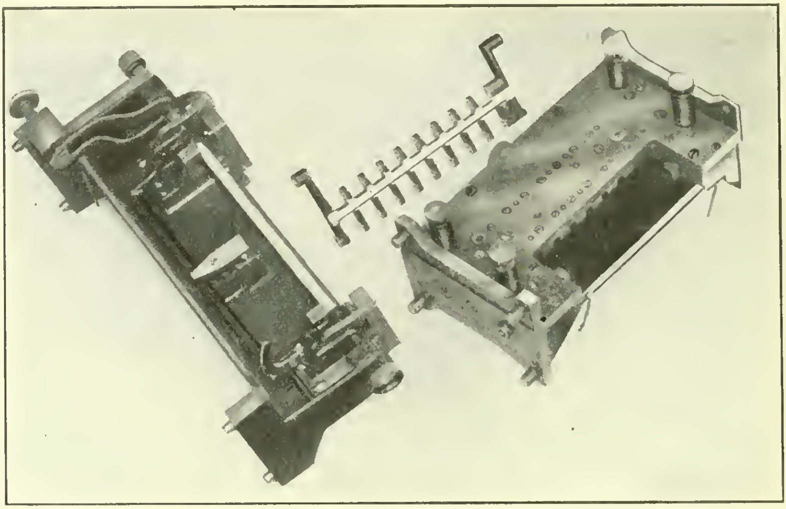


Fig. 15 Assembling Drill Jig and Drill Jig for A 48 and 48 A

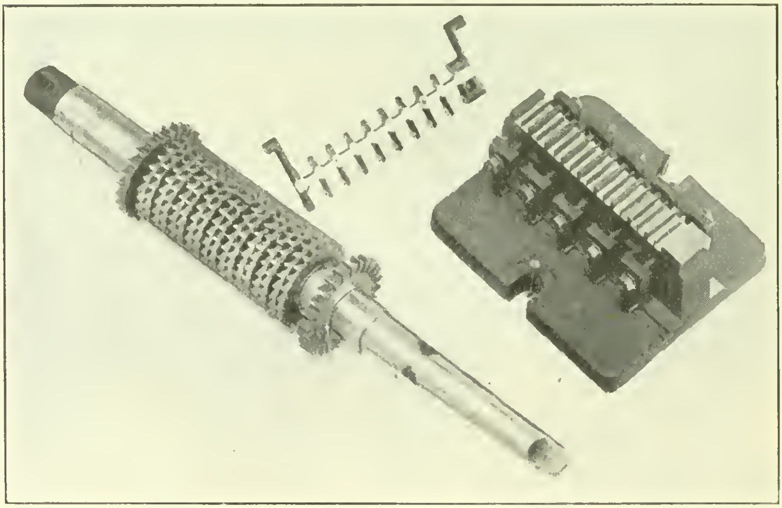


Fig. 16 Milling Fixtures and Gang Cutters for A 48 and 48 A

by screws A 29, and the springs A 82 are connected at their free ends to the small pins 12 A of the pieces A/3. There are nine pieces A/20 employed and to fill up the gap which would otherwise be occupied by the piece A/3, an extra hub A 33 is inserted in the space between

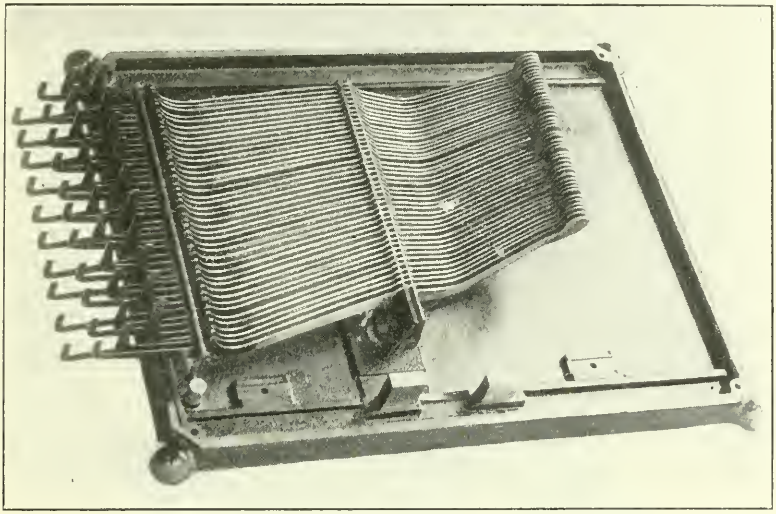


Fig. 17 Section B/30

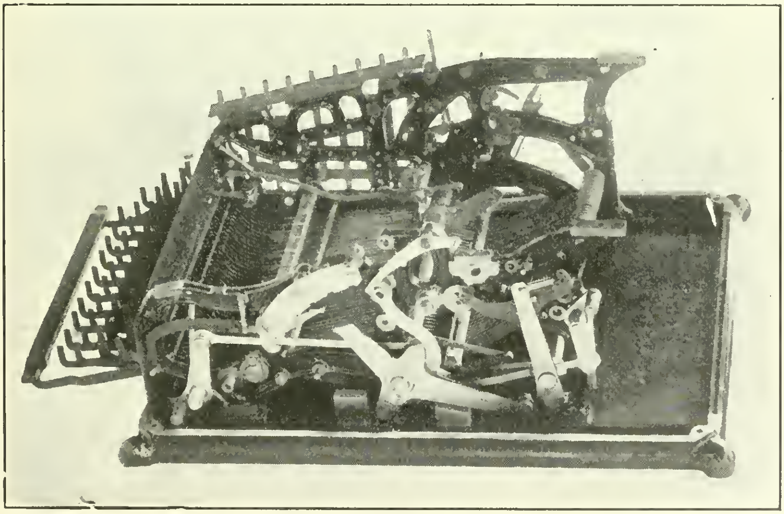


Fig. 18 Section B/50—First Operation

the piece A/20 and the side of A 48. In the same way the adding wheels A 50, their side carrying cams A 51, are mounted on the hubs A 34 and secured by rivets A 10, forming a piece A/1, and a suitable bearing rod A/5 serves as a pivot about which these wheels A/1 can revolve, shaft A/5 being inserted through holes in the end of the piece A/40. When these wheels are mounted on the shaft A/5, in the section A/40, the piece is complete and becomes A/50. This is known as a sub-section, which is a complete unit in itself, but goes to form a main section.

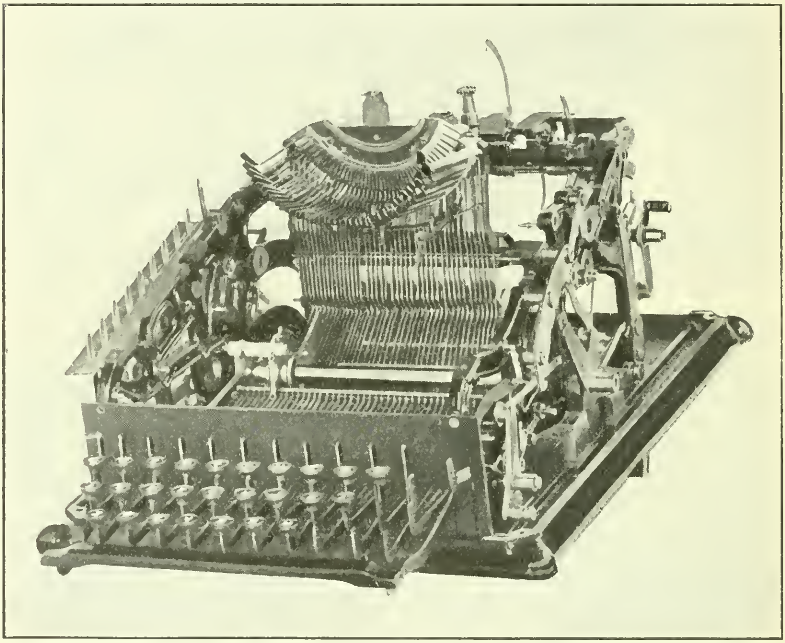


Fig. 19 Section B/50—Second Operation

20 There are two complete and independent adding devices in this machine, made right-handed and left-handed, not in all respects identical. Fig. 10 shows the parts for sub-sections A/24 and A/33, to be assembled left-handed, and the progressive stages in assembling.

21 This method of illustrating the different steps in the assembling and the use of charts (Fig. 11) to simplify the explanation to the workmen is found very useful. It has not come within the writer's experience to find a man capable of carrying this mass of detail in his head

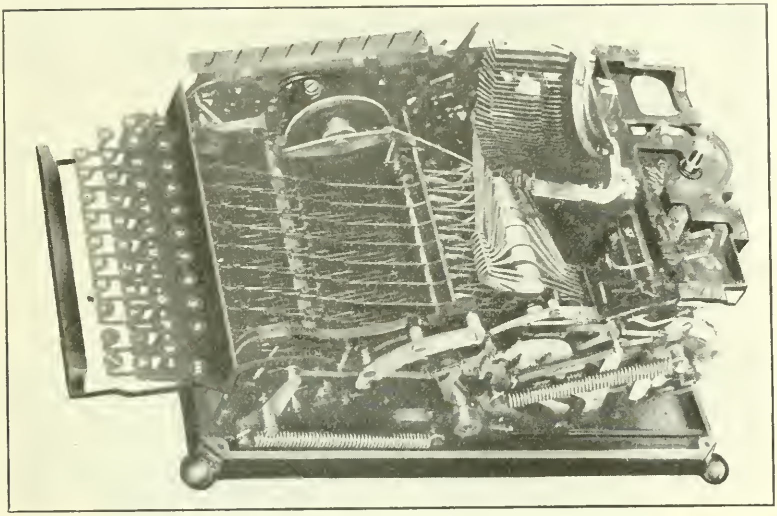


FIG. 20 SECTION B/50 THIRD OPERATION

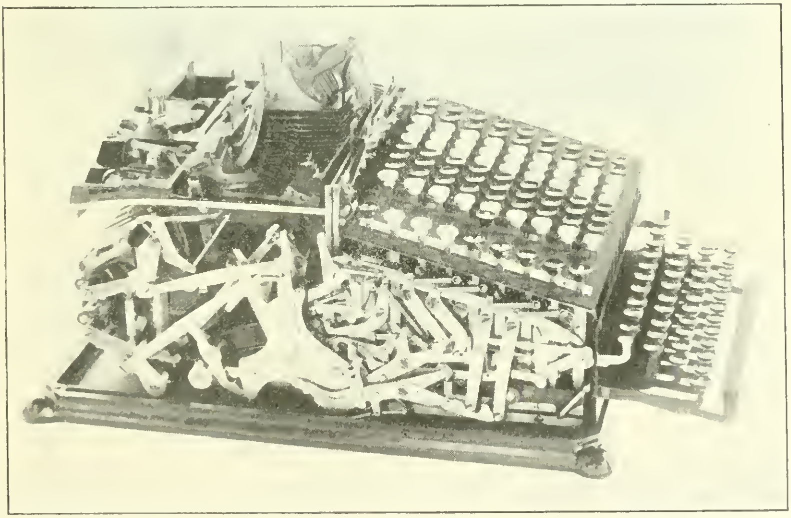


FIG. 21 SECTION B/60—VIEW OF LEFT-HAND SIDE

unless aided by the best memorandum system that can be devised. Of such methods the photographic chart system is the most comprehensive that the writer has so far considered.

22 After the sub-sections are assembled, they are gathered together as shown in Fig. 12, and this forms a complete working unit known as a section. This unit is interchangeable on different machines and can be detached by the removal of six screws. The other individual sections of this machine are assembled in the same general way.

23 Some of the details of the production of the individual pieces, and the assembling of these pieces are shown. The testing gage for the pieces A 51 and 51 A is shown in Fig. 13. This is a compound-lever testing gage which magnifies the reading 100 times, and the error is 0.01 of the space indicated on the dial by the pointer. Other test gages, simple and compound, are shown in Fig. 14. In Fig. 15 is shown an assembling drill jig, and a drill jig for the pieces 48 A. In Fig. 16 is shown a milling fixture for the piece A 48 and 48 A and a typical gang mill.

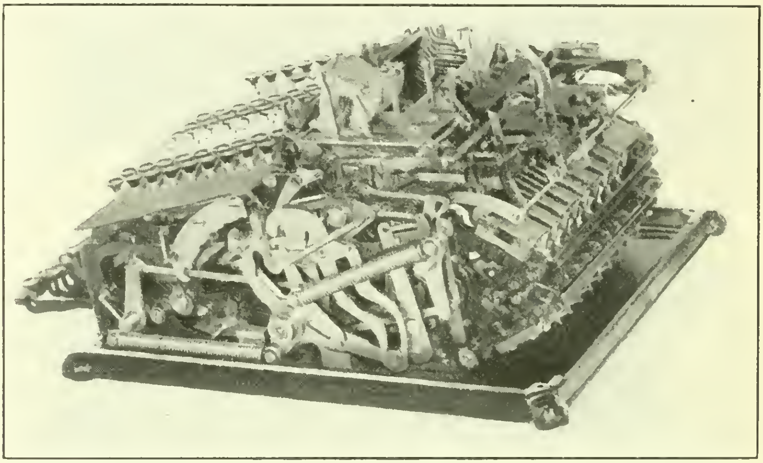


Fig. 22 Section B/60—View of Right Hand Side

ASSEMBLING THE COMPLETED MACHINE

24 The assembling of a completed machine starts with the base, on which are mounted the typewriter key levers, as shown in Fig. 17. The next step is to mount the two side frames B 46 and B 47 thereon, after which the parts between the side frames are inserted, and connected to the side frames, Fig. 18. The escapement, known as the E/60 section, is next mounted on the side frames, the typewriter connec-

tions are put in, and the machine assumes the appearance indicated in Fig. 19. The next step in assembling is the insertion of the R section or parts, consisting of the racks, the reducer arms, and the governor, all of which are shown in Fig. 20. The next two sections to be inserted are the F/70 section, and the P/70 or printing section of the adding machine. There remain the K and A sections, which are easily and quickly connected. The machine then assumes the appearance shown in Figs. 21 and 22, and is ready to have the case fitted over it and to have the carriage mounted upon it.

25 It may sound rather platitudinous to remark that the mechanical and commercial possibility of the manufacture of a machine of this kind resolves itself into a question of system; not so much a system in the putting of the parts together as the system required in designing the machine in the first place so that the assembling can be properly sub-divided and each section tested for its ultimate fitness in the complete machine.

THE PRESSURE-TEMPERATURE RELATIONS OF SATURATED STEAM

By Lionel S. Marks

ABSTRACT OF PAPER

There has been great uncertainty as to the pressure-temperature relations of saturated steam in the range from 400 deg. fahr. to the critical temperature, owing to the considerable differences between the observations of different investigators. The new and authoritative work of Holborn and Baumann appears to have covered this range with great accuracy; their results are consequently presented to the Society.

With this new material the pressure-temperature relations of saturated steam are established satisfactorily from 32 deg. fahr. up to the critical temperature. It is found that these relations can be expressed by an equation of simple form based upon Van der Waals equation of corresponding states. The values of the pressure derived from this equation have a maximum difference from the best experimental values of about $\frac{1}{10}$ of one per cent in the range from 212 deg. fahr. to the critical temperature (706.1 deg. fahr); below 212 deg. fahr. the maximum difference is 0.196 per cent at 50 deg. fahr. corresponding to a pressure difference of 0.00035 lb. per sq. in.

THE PRESSURE-TEMPERATURE RELATIONS OF SATURATED STEAM

By Lionel S. Marks, Cambridge, Mass.
Member of the Society

The relation between the pressure and temperature of saturated steam is known with great accuracy for the range of temperatures from 32 deg. to 400 deg. fahr., or for the approximately corresponding pressure range from 0.1 lb. to 250 lb. per sq. in. abs. Within that range the experimental values of Regnault and of other investigators agree very closely with the recent and authoritative work of Scheel and Heuse[1] and of Holborn and Henning.[2] It is probable that the temperature corresponding to any pressure within that range is now known accurately to within $\frac{1}{20}$ deg. fahr.

2 At higher pressures and temperatures there is no such agreement between the results of different investigations. Until the past year the most important work in this part of the field had been done by Battelli, by Cailletet and Colardeau and by Knipp. Table 1 (from Marks and Davis' Steam Tables, p. 95) shows the very considerable divergence between the results obtained by these three investigations, particularly at the higher temperatures.

TABLE 1 PRESSURE OF SATURATED STEAM AT HIGH TEMPERATURES

Temperature, Deg. Fahr.	Pressures in Atmosphere according to		
	Battelli	Cailletet and Colardeau	Knipp
400	16.8	16.8	.....
500	48.6	46.6	47.1
600	109.7	107.1	112.5
680	186.7	189.0	207.7

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[1] Annalen der Physik, 1910, vol. 31, pp. 715-735. The range covered was from 32 deg. to 122 deg. fahr.

[2] Annalen der Physik, 1908, vol. 25, pp. 833-883. The range covered was from 122 deg. to 400 deg. fahr.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

3 During the past year there have been published[1] the results of an investigation carried out at the Reichsanstalt by Holborn and Baumann on the pressure-temperature relations of saturated steam from 400 deg. fahr. to the critical temperature. Considerable weight must certainly be given to any investigation coming from that source and in this particular case, all the internal evidence would indicate that more weight should be given to these results than to those of any of the previous investigators. Of the earlier investigations, the internal evidence clearly indicated that the work of Cailletet and Colardeau was probably the most accurate and for that reason their results have been adopted in recent steam tables. The new values by Holborn and Baumann differ markedly from the values obtained from the three earlier investigations, but are much closer to the values of Cailletet and Colardeau than to the others. It seems worth while to describe briefly the methods and results of this new work.

4 The measurement of vapor pressure may be either by the statical or the dynamical method. In the statical method the liquid and its vapor are maintained at constant temperature and the corresponding pressure is measured. The simplest example of the statical method is that used by Regnault in his experiments with low-pressure steam. For this work the liquid was inserted above the mercury in a barometer tube, the upper part of which was kept in a constant temperature bath; the depression of the mercury column measured the vapor pressure corresponding to the temperature of the bath. In the dynamical method the pressure is kept constant and the corresponding temperature measured. The pressure is maintained by air or other gas acting on top of the liquid, the liquid is heated continuously, and the vapor which forms is condensed continuously and is returned by gravity. The process is similar to that customarily employed for the determination of boiling points at atmospheric pressure, an artificial atmosphere of any desired pressure being maintained over the liquid.

5 The work of Holborn and Henning on saturation pressures from 120 deg. to 400 deg. fahr. was by the dynamical method. This new work by Holborn and Baumann is by the statical method. The water was contained in a steel vessel surrounded by a constant temperature bath; absolute measurements of the pressure were obtained by means of a weighted rotating plunger; the volume of water

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[1] Annalen der Physik, 1910, vol. 31, pp. 945-970.

in the vessel could be varied either continuously at an approximately uniform rate, or intermittently.

6 In presenting their results, Holborn and Henning used as a standard of reference the following formula of Thiesen:—

$$(t+273)\ \log\frac{p}{760}=5.409\ (t-100)\ -0.508\times10^{-8}\ [(365-t)^4-265^4]$$

in which the pressure p is in mm. of mercury at 0 deg. cent. and the temperature t is in deg. cent. The deviation of their experimental values of the temperature from those calculated from the formula is small and is given by a correction curve.[1] The Thiesen formula also fits the Scheel and Heuse results up to 120 deg. fahr. with great exactness. Holborn and Baumann have followed a similar procedure in presenting their results for temperatures above 400 deg. fahr.

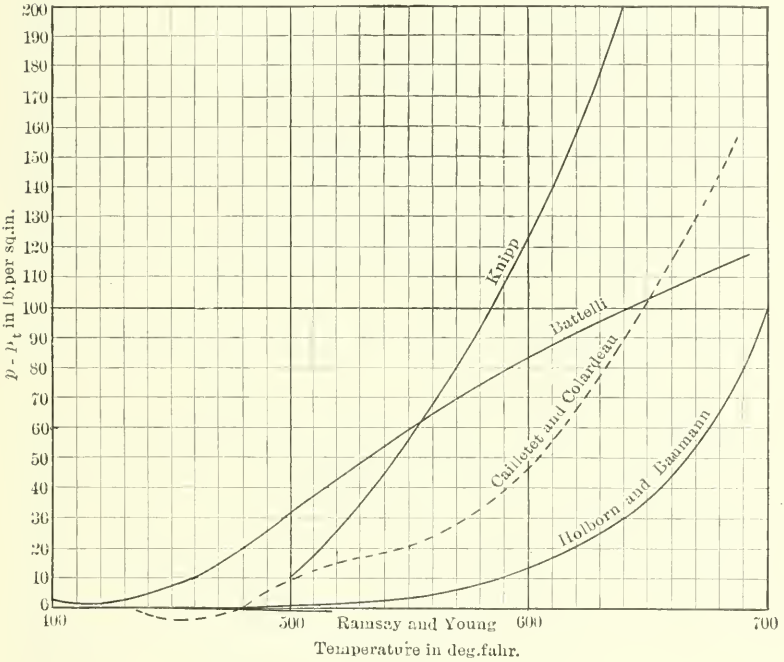

Fig. 1 Curves Showing Deviation of Pressure p Observed by Various Investigators from Pressure p_t Calculated from Modified Thiesen Equation for Temperature above 400 deg. fahr.

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[1] Marks and Davis' Steam Tables, p. 94.

The equation they have adopted as a standard of reference is a modification of the Thiesen equation. Their equation is

$$(t+273) \log \frac{p}{1.0333} = 5.3867\ (t-100)-0.5262 \times 10^{-8}\ [(365-t)^4-265^4]$$

where p is in kg. per sq. cm. and t is in deg. cent.

7 This new equation fits the experimental data extremely well from 212 deg. to 400 deg. fahr. The maximum difference between the observed and calculated pressures at any temperature within that range is 2 mm. of mercury or about 0.04 lb. per sq. in. At temperatures in excess of 500 deg. fahr. this equation does not give good results and its error increases very rapidly as the temperature increases beyond that value. The difference between the observed pressures and those calculated from the above equation are shown graphically in Fig. 1. There is also added for comparison the corresponding deviations of the experimental values of Battelli, of Cailletet and Colardeau, of Knipp, and of Ramsay and Young from the same equation. It is obvious at once how great is the discrepancy between these various experimental results, and it is also evident that the results of Cailletet and Colardeau agree much better with the latest work than do the others. The agreement with the results of Ramsay and Young, which extend only to about 520 deg. is good.

8 Holborn and Baumann have presented their results in tabular form. A column in Table 3 gives their results in English units, as deduced from their table by interpolation. It gives the pressures corresponding to each 10 deg. fahr. from 400 deg. fahr. to the critical temperature. As the second differences in the original table do not run smoothly, it will be found that the same is true of the second differences in this table. The values determined by Cailletet and Colardeau are included in the same table for purposes of comparison.

9 There is but little doubt that these new values should be accepted in preference to all earlier values. It is probable that they are not final; the investigators noted, contrary to the observations of earlier investigators, that the water acted on the walls of the steel vessel and that after repeated heatings over 570 deg. fahr. a small quantity of iron went into solution in the water and that the water became colored on standing in the air. There was evidence also that gas was formed in the vessel as a result of this action. It is possible that the same actions have taken place with the earlier investigations in which steel vessels were used, but that they passed unnoticed. Notwithstanding this evidence of the presence of small quantities of impurities in the vessel at the highest temperatures, it seems prob-

able that the results have a high order of accuracy. The probable degree of accuracy is so high that it is doubtful indeed whether any other investigator will be tempted to explore this field for a long time.

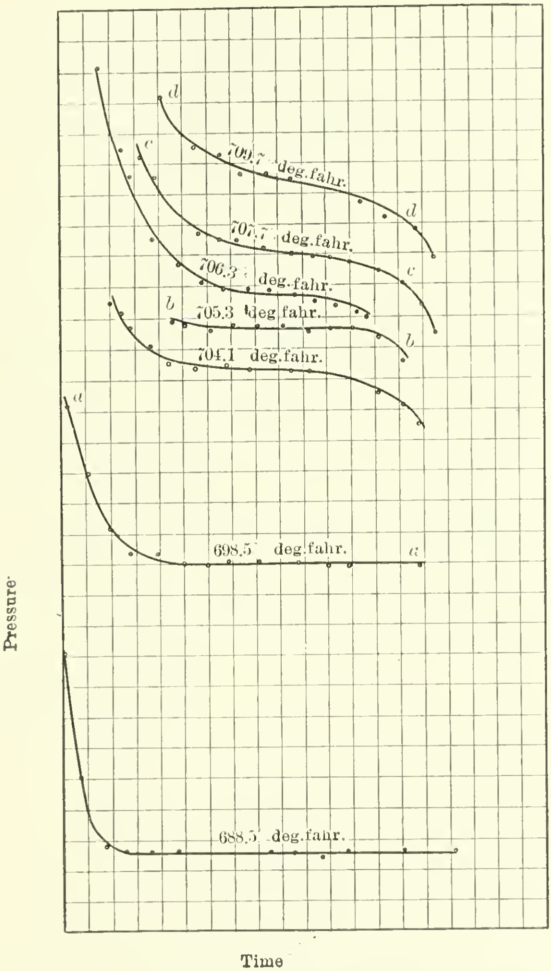

FIG. 2 ISOTHERMALS FOR STEAM—HOLBORN AND BAUMANN

10 It has been previously noted that there was in this investigation the possibility of varying continuously and at an approximately constant rate, the amount of water contained in the steel vessel. If the vessel is initially full of water at a pressure in excess of the

saturation pressure corresponding to the constant temperature at which the vessel is being kept, the gradual outflow of water will result in a fall of pressure until the saturation pressure is reached. Evaporation will then take place and the pressure will remain steady until all the water has escaped. If the pressures are observed and are plotted against time, the observations will give curves such as *aa*, *bb*, Fig. 2. These are isothermal curves and will be true pressure-volume curves if the rate of outflow of the water is kept constant. If the rate of outflow is not constant, as in these investigations, the curves will be altered in shape, but nevertheless have a horizontal part.

11 If the vessel is maintained at a temperature in excess of the critical temperature and the fluid contents of the steel vessel are permitted to flow out at a constant rate, the pressure curve will be such as *cc* or *dd*, and will not have any constant pressure, or horizontal section, since there cannot be any evaporation. The variation of pressure with time was investigated for a number of different isothermals in the vicinity of the critical temperature with the results shown in Fig. 2. They indicate that the critical temperature of water is about 374.6 deg. cent. or 706.3 deg. fahr. and the corresponding pressure 225 kg. per sq. cm. or 3200 lb. per sq. in.

12 The critical constants as determined in this way differ from the earlier values. The more important of these are given in Table 2.

TABLE 2 CRITICAL DATA FOR WATER

Investigator	Date	Critical Temperature, Deg. Fahr.	Critical Pressure, Lb. per Sq. In.
Nadejdine	1885	676.6	....
Battelli	1890	687.7	2859
Cailletet and Colardeau	1891	689	2944
Traube and Teichner	1904	705.2	....
Holborn and Baumann	1910	706.3	3200

13 It will be seen that the critical values have been continuously raised by the later investigators. The practical agreement of the last two determinations of the critical temperature is probably indicative of a fairly correct value. The method of Holborn and Baumann is well adapted to give good results.

14 Accepting the data of Holborn and Henning and of Holborn and Baumann as the best available, and as probably of very considerable

accuracy, it becomes interesting to ascertain whether any formula can be found to represent them accurately. Most of the formulae which have been suggested become quite inaccurate above 400 deg. fahr. Professor Robert H. Smith[1] has suggested the formula

$$p = -0.16 + 0.0075\,t + 2.816 \times 10^{-10}\,t^{4.588}$$

which fits the Cailletet and Colardeau values extremely well up to 600 deg. fahr. with a maximum error of 0.3 lb. per sq. in. at 300 deg. fahr., but with large errors above 600 deg. fahr. The writer has not tried an equation of that general form with the new values; but there is little doubt that a satisfactory equation of that form could be found. It has seemed better, however, to proceed along different lines in looking for the desired equation.

15 The pressure and temperature of a substance can be expressed in terms of any unit. In seeking for a form of statement of the pressure-temperature relations of a saturated vapor, which may possibly apply to the vapors of many, or even of all substances, it is desirable to express the pressures and temperatures *not* as multiples of the usual units (lb. sq. per in. and deg. fahr.), but as fractions of the absolute critical pressure and temperature of the substance under consideration. Taking 3200 lb. per sq. in. and 1106 deg. fahr. as the critical constants for water, a pressure of 1600 lb. per sq. in. becomes 0.5 in the new units, and an absolute temperature of 553 deg. has the same value in the new units. Pressures and temperatures expressed in these units are called reduced pressures and temperatures, and substances at the same reduced pressures and temperatures are said to be in corresponding states.

16 There has been considerable speculation as to the relations between the properties of substances which are in corresponding states. The most obvious hypothesis, suggested by a cursory examination of the saturation data for various substances, is that substances at the same reduced temperatures have the same reduced pressures. For example, water at a reduced temperature of 0.7 (=816.4 deg. abs.) has a pressure of 146 lb. per sq. in. or a reduced pressure of 0.0456. Ammonia (critical temperature 730 deg. abs., pressure 1690 lb. per sq. in.) at a reduced temperature of 0.7 (511 deg. abs.) should have according to this hypothesis, the same reduced pressure (0.0456) or a pressure of 77.1 lb. per sq. in. The observed pressure is, however, 90.7 lb. per sq. in. The hypothesis will be found to give only a very

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[1] The Engineer (London), August 26, 1910.

rough approximation to the observed facts in many cases. If the hypothesis were true we should have the equation

$$\frac{p}{p_c} = f\left(\frac{T}{T_c}\right)$$

where p_c and T_c are the critical constants and p is the absolute saturation pressure corresponding to any absolute temperature T.

17 Van der Waals[1] assumes the equation given in Par. 16 to have the special form

$$\log \frac{P_c}{p} = a\left(\frac{T_c}{T} - 1\right)$$

where a is a constant with the same value for all substances, with an approximate value of 3. This equation gives results which are near enough to the facts to suggest that it has some logical basis, but which gives errors too great for practical use. It has the positive merit of being accurate at the critical temperature, but it is found that the value of the constant a differs with the substance. Nernst[2] gives the following values of a which, he says, hold for the range $\frac{T_c}{T} = 1.5$ to 2.0, a range which is the important range for water.

Hydrogen	1.83
Argon	2.17
Nitrogen	2.45
Oxygen	2.53
Carbon bi-sulphide	2.63
Chloroform	3.00
Ether	3.15
Propylacetate	3.39
Ethyl alcohol	4.05

He gives also a series of curves, Fig. 3, which seem to show a straight line relation between $\log \frac{p_c}{p}$ and $\left(\frac{T_c}{T} - 1\right)$.

18 If the van der Waals equation were true for all these substances, the lines would all be straight lines; and if a were constant they would be superposed. Applying the equation to saturated steam and finding the values of a corresponding to different reduced temperatures, it becomes evident at once that a is not a constant, but

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[1] Continuität der gasförmigen und flüssigen Zustandes, p. 147.

[2] Gottingische Nachrichten, Math.-Phys. Klasse 1906.

varies as in the curve, Fig. 4. This curve goes through a minimum for a value of $\frac{T}{T_c}$ approximately of 0.78. The curve suggests that a varies with $\frac{T_c}{T}$ according to the equation

$$a = b\left[1 + c\frac{T}{T_c} + d\left(\frac{T}{T_c} - 0.78\right)^2\right]$$

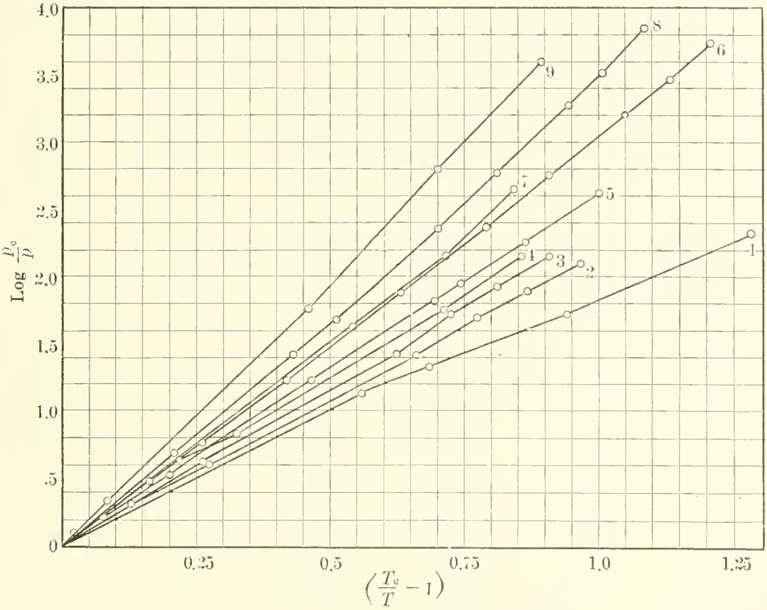

FIG. 3 CURVES SHOWING APPLICABILITY OF VAN DER WAALS EQUATION TO (1) HYDROGEN, (2) ARGON, (3) KRYPTON, (4) OXYGEN, (5) CARBON BI-SULPHIDE, (6) FLUORBENZOL, (7) ETHER, (8) PROPYLACETATE, (9) ETHYL ALCOHOL, TAKEN FROM NERNST

where b, c and d are constants. By a few trials it was found that 0.7875 gave somewhat better results than the approximate value of 0.78 in the last term. The van der Waals equation as modified for the variation of a becomes

$$\log\frac{p_c}{p} = b\left[1 + c\frac{T}{T_c} + d\left(\frac{T}{T_c} - 0.7875\right)^2\right]\left(\frac{T_c}{T} - 1\right)$$

19 This equation is very sensitive to slight variations in the assumed values of the critical constants. Assuming the critical pres-

sure to be 3200 lb. per sq. in., the corresponding critical temperature which was found to give calculated results in closest accord with the experimental results was 706.1 deg. fahr. A variation of $\frac{1}{10}$ deg. fahr. in the assumed critical temperature has a very marked effect on the calculated pressures at the highest temperatures. The value of the critical temperature given by Holborn and Baumann is 706.3

TABLE 3 EXPERIMENTAL AND CALCULATED PRESSURES OF SATURATED STEAM FROM 400 DEG. FAHR. TO THE CRITICAL TEMPERATURE

Temperatures, Deg. Fahr.	Pressures, Lb. per Sq. In.			Deviation of Formula From Holborn and Baumann	
	Cailletet and Colardeau	Holborn and Baumann	By Formula	Lb. per Sq. In.	Percentage
400	247.1	246.99	247.10	+0.11	0.044
410	276.4	276.34	276.47	+0.13	0.047
420	308.4	308.33	308.47	+0.14	0.045
430	343.2	343.18	343.26	+0.08	0.023
440	380.8	380.92	381.02	+0.10	0.026
450	421	421.85	421.87	+0.02	0.0047
460	465	465.95	466.04	+0.09	0.019
470	573	513.65	513.66	+0.01	0.0019
480	565	565.08	564.93	−0.15	−0.026
490	622	620.18	620.05	−0.13	−0.021
500	684	679.26	679.18	−0.08	−0.012
510	751	742.55	742.56	+0.01	0.0013
520	822	810.31	810.37	+0.06	0.0074
530	897	882.58	882.82	+0.24	0.027
540	977	959.85	960.15	+0.30	0.031
540	1062	1042.2	1042.6	+0.4	0.038
560	1152	1130.2	1130.3	+0.1	0.0089
570	1247	1223.7	1223.7	0	0
580	1349	1323.0	1322.9	−0.1	−0.0076
590	1458	1428.3	1428.1	−0.2	−0.14
600	1574	1539.9	1539.8	−0.1	−0.0065
610	1697	1657.8	1658.1	+0.3	0.018
620	1827	1782.9	1783.3	+0.4	0.022
630	1965	1915.3	1915.9	+0.6	0.031
640	2111	2055.1	2056.0	+0.9	0.044
650	2265	2203.1	2204.2	+1.1	0.049
660	2428	2359.2	2360.5	+1.3	0.055
670	2599	2523.4	2525.6	+2.2	0.067
680		2697.1	2699.7	+2.6	0.096
690		2882.3	2883.3	+1.0	0.035
700		3080.4	3076.8	−3.6	−0.117
706.1		3200.0	3200.0	0	0

deg. fahr., but it is certain that their method cannot give results which are reliable to within a few tenths of a degree. It is probable that an equation which fits the experimental facts for a range of over 600 deg. fahr. may be extrapolated with some certainty for 20 deg. or 30 deg. In obtaining the constants in the equation it was consequently assumed that the critical temperature was 706.1 deg. fahr. or

$$T = 706.1 \text{ deg.} + 459.64 \text{ deg. fahr.}$$

After numerous trials the following equation was finally adopted

$$\log \frac{p_c}{p} = 3.006854 \left(\frac{T_c}{T} - 1 \right) \left[1 + 0.0505476 \frac{T}{T_c} + 0.629547 \left(\frac{T}{T_c} - 0.7875 \right)^2 \right]$$

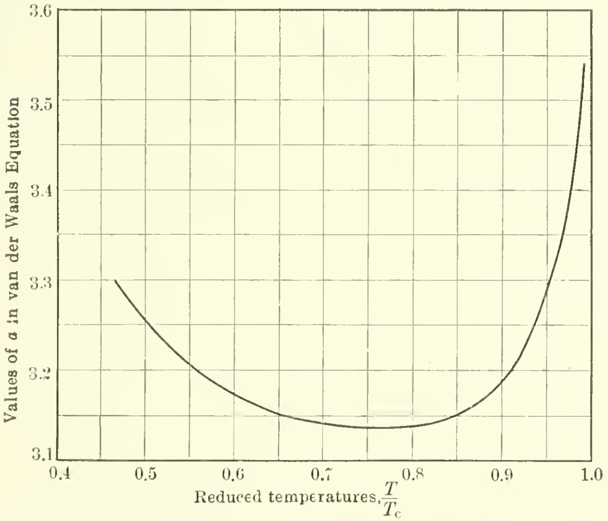

FIG. 4 CURVE SHOWING VARIATION OF a IN VAN DER WAALS EQUATION FOR SATURATED STEAM

Inserting the chosen values of the critical constants this reduces to

$$\log p = 10.515354 - 4873.71\, T^{-1} - 0.00405096\, T + 0.000001392964\, T^2$$

20 The agreement of the pressures calculated from this equation with the experimental results of Holborn and Baumann is very striking and is shown in Table 3, which gives the calculated pressures and the differences from the experimental results, expressed both in lb.

per sq. in. and in percentages. It will be seen that from 400 deg. to 650 deg. the difference is nowhere so great as $\frac{1}{20}$ of 1 per cent. From 650 deg. to the critical temperature the maximum difference is slightly greater than $\frac{1}{10}$ of 1 per cent but becomes zero at the critical temperature. The curve, Fig. 5. shows the difference in lb. per sq. in. It is probable that but little weight should be given to the differences in the neighborhood of the critical temperature in view of the decreasing accuracy of the experimental results in that vicinity.

TABLE 4 EXPERIMENTAL AND CALCULATED PRESSURES OF SATURATED STEAM FROM 32 DEG. TO 400 DEG. FAHR.

Temperatures, Deg. Fahr.	Pressure, Lb. per Sq. In.		Deviations of Formula From Tabulated Values	
	Marks and Davis' Steam Tables	By Formula	Lb. per Sq. In.	Percentage
32	0.0886	0.088563	−0.000037	−0.042
50	0.1780	0.17765	−0.00035	−0.196
100	0.946	0.946	0	0
150	3.714	3.707	−0.007	−0.188
200	11.52	11.504	−0.016	−0.139
250	29.82	29.802	−0.018	−0.060
300	67.00	67.00	0	0
350	134.6	134.60	0	0
400	247.1	247.10	0	0

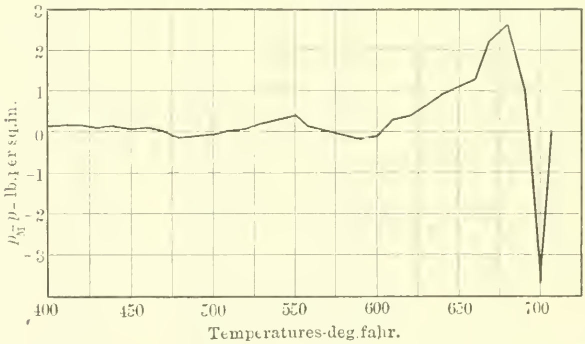

Fig. 5 Curve Showing Difference between Calculated Pressure p_m and Observed Pressure p_1 for Temperature Range from 400 deg. fahr. to the Critical Temperature

21 Below 400 deg. fahr. the agreement of the equation with the experimental results is shown in Table 4. The experimental results are those of Holborn and Henning from 120 deg. to 400 deg., and of Regnault and other investigators below 120 deg. The differences are very small as expressed in lb. per sq. in., but amount nearly to $\frac{1}{5}$ of 1 per cent in some cases. These differences are not greater than the variations among the best experimental values in this part of the temperature range. For example, the new and excellent work of Scheel and Heuse gives a pressure of 0.088444 lb. at 32 deg. fahr. as against 0.0886 lb. given in Table 4 (from Regnault's work) and 0.088563 lb. calculated from the equation. The equation value is almost exactly the mean of the two experimental values.

22 The equation given in Par. 19 has, it is believed, the advantage over previous equations of greater simplicity, greater accuracy, and also of the great ease in finding $\frac{dp}{dt}$ for use in the Clapeyron equation.

23 I am indebted to H. J. Macintire, Jun.Am.Soc.M.E., for most of the numerical work in obtaining the equations.

FIRES: EFFECTS ON BUILDING MATERIALS AND PERMANENT ELIMINATION[1]

By Frank B. Gilbreth, Published in The Journal for May, 1910

ABSTRACT OF PAPER

The author calls attention to the enormous annual fire loss amounting to over $456,000,000, during 1907, in addition to which 1449 persons were killed and 5654 were injured in fires. If buildings in this country were as nearly fireproof as in Europe the fire loss would be $90,000,000 and the United States is therefore paying a preventable tax of over $366,000,000. As a result of painstaking observation at a number of the great fires, the author believes that no structure of the future should be built of wood or contain any wood, and he states that the increasing cost of lumber and the improved methods of fireproof construction have made it possible to build non-combustible structures at no greater cost than wooden ones. The disuse of wood in building construction would mean the saving of forests, uninterrupted business, the saving of life, the saving of buildings and the saving of the contents of buildings. The author believes that the permanent elimination of fires can never be thoroughly and completely brought about without Governmentaid and suggests the following lines along which Government assistance can be directed: *a*, by passing laws restricting the use of wood in buildings; *b*, by levying taxes discriminating in favor of fireproof houses and against wood in construction; *c*, by educating the people by Government documents on how to build fireproof houses.

DISCUSSION AT NEW YORK[1]

J. P. H. Perry.[2] A fire in the Dayton Motor Car Company works, at Dayton, O., about eighteen months ago started on the fourth floor of the new reinforced-concrete factory and from there spread into the first-class brick and mill-construction building adjoining. The concrete building was so new that although the sprinkler system had been

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[1] This paper was presented in New York, October 11, 1910, and in St. Louis, October 15, 1910, at a meeting of the Society with the Engineers' Club of St. Louis coöperating. The discussion at both meetings has been combined.

[2] Manager Contract Dept., Turner Construction Co., New York.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

installed, it had not yet been connected; neither had the automatic fire doors, protecting the openings from the new into the old building, been put in place. The fire entirely gutted the fourth floor of the concrete building and destroyed the roof, fourth and third floors of the brick building, cracking the walls and practically ruining the building. Despite the severity of the fire in the concrete building, it was only two days after the fire before the owners began to install new machinery on the burned-out floor, Little or no repairs were necessary.

One of the buildings which survived the Baltimore fire had a structural frame of reinforced-concrete columns, beams, etc., but the walls were of brick. These last collapsed, although the concrete portion remained in place, surviving the fire without serious damage.

Fire tests of concrete structures, similar to these two, occurred in the glue factory of F. W. Tunnell Company, near Philadelphia, and the Thompson and Norris Buildings, Brooklyn. In both cases the test was a severe one and yet concrete demonstrated indisputably its value as a fire-resistant material.

Not infrequently one hears statements to the effect that concrete construction is slow and in several instances to my knowledge structural steel or mill construction has been adopted because of the imagined length of time reinforced concrete would take. As a matter of fact, for rebuilding after fires concrete compares well with any other type of building. Work can be started on the foundations as soon as the débris of the building destroyed by fire has been removed, and without waiting for complete plans to be prepared, steel to be detailed, rolled and fabricated at the mills, as is the case of structural steel. I do not intend to convey the impression that a concrete frame work will go up as fast as structural steel, but the time of completion compares well with other types.

It is frequently said that it is difficult to make changes in concrete buildings, such as installing sprinkler or plumbing pipes, or running shafting, or setting motors in place, where they had not originally been intended. In Figs. 16 and 17 are given a few typical details showing how this problem has been most satisfactorily solved in a great number of concrete buildings already erected in this territory. The best answer to complaint by the uninformed on this property of concrete is reference to the great Bush Terminal buildings in Brooklyn. These buildings will aggregate, when those in construction at the present time are completed, some 79 acres of floor space, all of which is for rental purposes. The owners in selecting reinforced concrete for these buildings had to meet the requirements of unknown tenants of many different kinds. Not only did the structural material selected have to be as fireproof as possible, but it also had to adapt

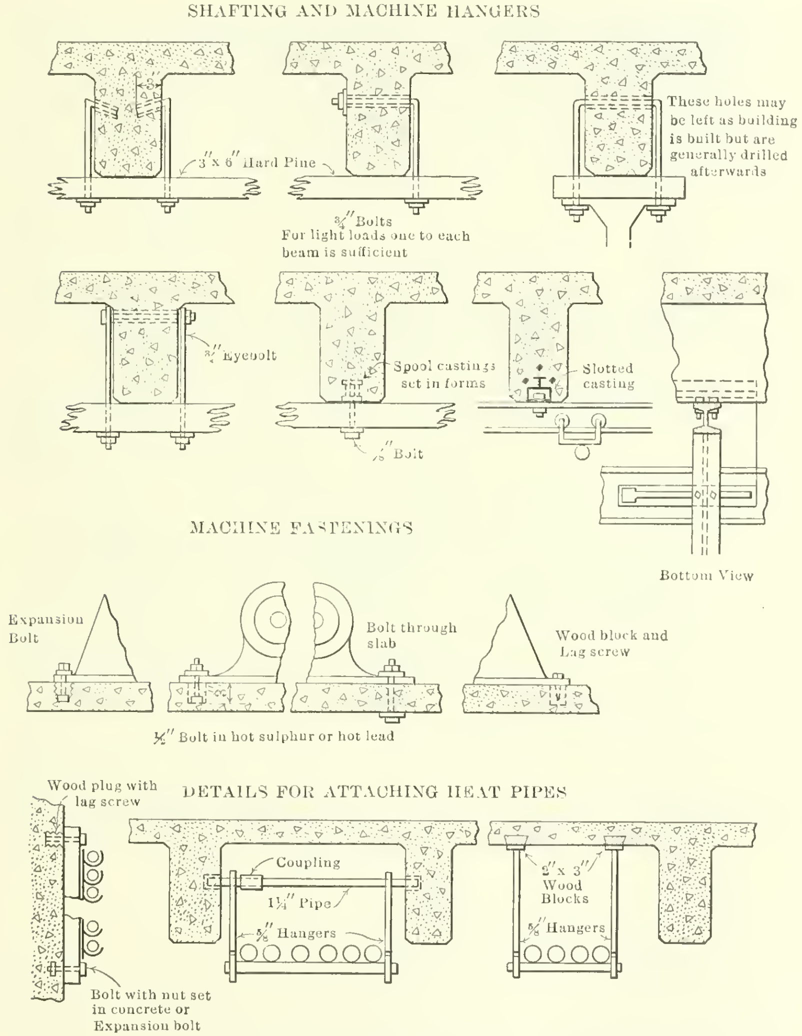
SHAFTING AND MACHINE HANGERS
3"
3" x 6" Hard Pine
3/4" Bolts
For light loads one to each beam is sufficient
These holes may be left as building is built but are generally drilled afterwards
3/4" Eyebolt
Spool castings set in forms
5/8" Bolt
Slotted casting
Bottom View
MACHINE FASTENINGS
Expansion Bolt
Bolt through slab
Wood block and Lag screw
1/2" Bolt in hot sulphur or hot lead
DETAILS FOR ATTACHING HEAT PIPES
Wood plug with lag screw
Coupling
1 1/4" Pipe
5/8" Hangers
2" x 3" Wood Blocks
5/8" Hangers
Bolt with nut set in concrete or Expansion bolt

FIG. 16 DETAILS OF HANGERS AND FASTENINGS IN CONCRETE BUILDINGS

itself readily to the needs of occupancy conditions probably of one hundred different classes of manufacturing and storage companies.

The continued construction of new buildings for this concern and the ease with which they are rented should furnish a most positive answer as to the satisfaction of reinforced concrete for industrial purposes.

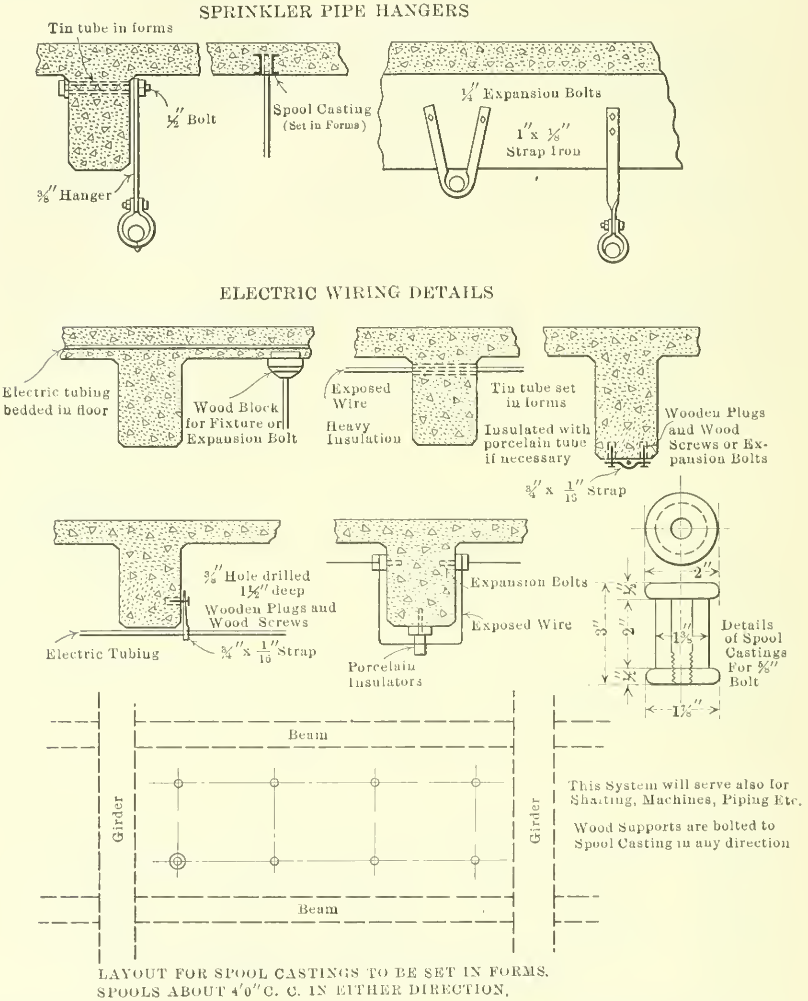
SPRINKLER PIPE HANGERS
Tin tube in forms
½" Bolt
⅜" Hanger
Spool Casting
(Set in Forms)
¼" Expansion Bolts
1" x ⅛"
Strap Iron
ELECTRIC WIRING DETAILS
Electric tubing bedded in floor
Wood Block for Fixture or Expansion Bolt
Exposed Wire
Heavy Insulation
Tin tube set in forms
Insulated with porcelain tube if necessary
Wooden Plugs and Wood Screws or Expansion Bolts
¾" x 1/16" Strap
⅜" Hole drilled 1½" deep
Wooden Plugs and Wood Screws
Electric Tubing
¾" x 1/16" Strap
Expansion Bolts
Exposed Wire
Porcelain Insulators
2"
⅜"
3"
2"
1⅜"
⅜"
1⅞"
Details of Spool Castings For ⅝" Bolt
Beam
Girder
Girder
Beam
This System will serve also for Shafting, Machines, Piping Etc.
Wood Supports are bolted to Spool Casting in any direction
LAYOUT FOR SPOOL CASTINGS TO BE SET IN FORMS.
SPOOLS ABOUT 4'0" C. C. IN EITHER DIRECTION.

FIG. 17 METHODS OF INSTALLING SPRINKLER PIPES, ELECTRIC WIRING AND MACHINERY IN CONCRETE BUILDINGS

I have just received reports of some tests of the waterproof character of concrete floors. In most fires the damage is quite largely that occasioned by water, and the tightness of concrete floors is very important. In the first four factories constructed for the Bush Terminal Company, wooden floors laid on sleepers were specified. In factories Nos. 5, 6 and 19 the owners have omitted the wooden floors and have substituted granolithic floor finish. This floor finish was not laid monolithic with the floor slab, as is customary, but instead, the granolithic finish, 1 in. in thickness, was laid on 2 in. of rich cinder concrete over the supporting slab. This change was made in spite of the imaginary objections of employees against concrete floors. An even more important factor in bringing about this change was the waterproof property of such construction. In one of the factories having wooden floors laid on wooden sleepers placed in cinder fill on the supporting stone concrete slab, there occurred recently a small fire. The water leaked through into the story below, coming through inevitable shrinkage cracks. The National Board of Fire Underwriters then took the stand that they would not quote minimum rates on these buildings unless waterproofing was laid under the floor sleepers so as to avoid possible water damage. To avoid this expense of waterproofing the character of floor finish above described was adopted. It had proved successful as a permanent finish on winter weather jobs, and it seemed worthy of consideration as being watertight.

Warehouse "A" of the Bush Terminal Company, which has this type of granolithic floor finish throughout, is a six-story and basement structure, 150 ft. sq. One entire floor, 22,500 sq. ft., was flooded with water. The floors pitch from the center to the wall scuppers about 6 in. These scuppers and the elevator and stair well openings were closed. Water to a depth of about 5 in. at the outside walls remained on the floor four days. The amount of water which leaked through the floor was very small and no water appeared on the ceiling below until the water had been on the floor for about five hours. This test was viewed by the underwriters and was pronounced extremely satisfactory. I understand that this type of floor construction has been approved as being waterproof.

H. de B. Parsons. The old adage, "an ounce of prevention is worth a pound of cure," contains much that is worth practicing. The ratio in the phrase is 1 in 16, but with fire risks it would seem truer to place the ratio at 1 in 100 and alter the phrase to suit, "a cent of prevention is worth a dollar of cure." Even that proportion of the cost of a building is rarely properly spent to reduce the fire hazard. Many owners of buildings spend large sums in fire apparatus, extinguishers and the like but the same amount of money and energy spent on original construction and design would have been more effective.

The value of a building depends on its income-earning capacity and it is a well established fact that safe buildings command little, if any, additional rent over those in which such qualities are but veneer. Tenants are guided chiefly by modern conveniences and showy appearances. Many imagine because iron and steel are incombustible that buildings constructed of such materials, together with glass, bricks and cement, can always be classified as fireproof. Such buildings may be proof against an internal fire when empty, but unfortu-

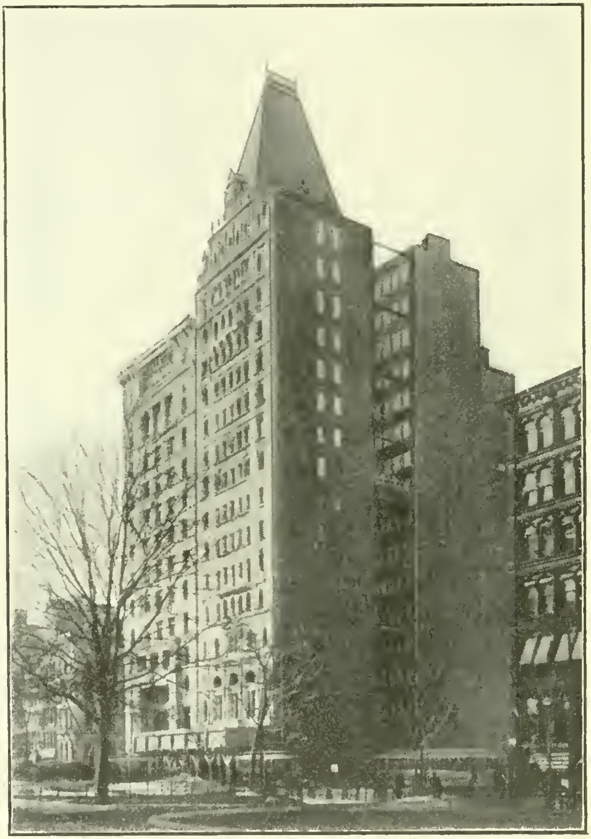

Fig. 18 Damage by Fire to Home Life Insurance Company's Building, New York City

nately, full consideration is not always given to the effect of inflammable contents or of the hazard caused by a neighboring structure.

The design of a real fireproof building is more difficult of execution than is generally imagined. The term fireproof has become generic and is, in many instances, a misnomer. In its broad sense it is used to classify a certain style of modern construction that has become very popular, as is attested by the wonderful and rapid increase of such buildings in our cities.

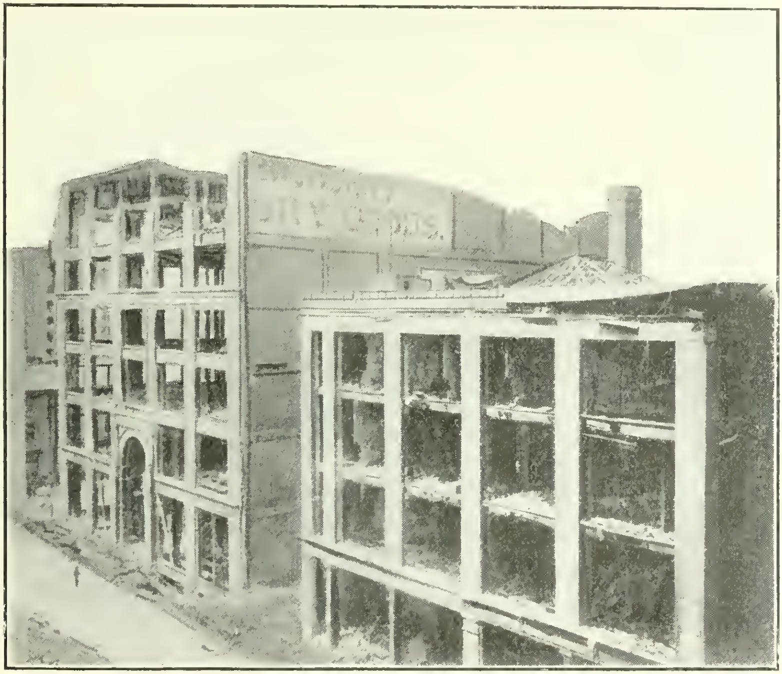

Fig. 19 The Horne Dry Goods Store and the Horne Office Building, Pittsburg, Showing Injury by Fire Originating in Other Buildings

It is impossible to conceive of a building that cannot be damaged by fire. The more fireproof a building is made the greater will be its cost and the less its utility for modern demands. The problem is economic and must be settled by balancing the questions involved.

A fireproof structure may then be defined as one that will be damaged by fire to a minimum extent, while considering the hazards from within as well as from without; one in which the injury will be localized; and one in which the main supporting or weight-carrying members will not be injured to an extent that will render them useless.

In 1896 The American Society of Mechanical Engineers entered into a joint committee with architectural and insurance interests for the purpose of making tests on structural material. The chief work of this committee is described in the Transactions of 1907. When unprotected steel or cast-iron columns were exposed to the direct action of heat and the heat was applied rapidly, the columns failed in less than 30 minutes from the application of the heat, or when they began to show red in the light of the flame.

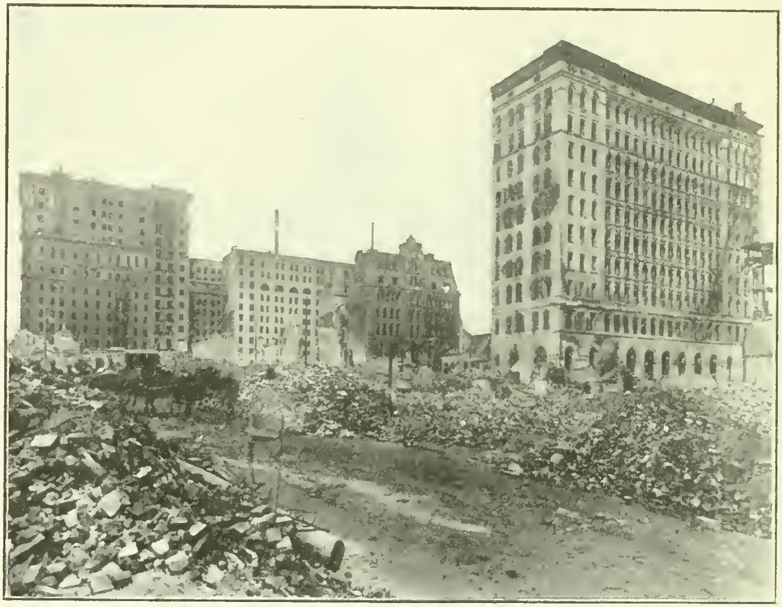

Fig. 20 So-Called Fireproof Buildings Badly Injured by Fire from Adjoining Structures

This same result was shown in the destruction by fire of a mill or steel and brick construction in Worcester, Mass. The steel work of this mill was unprotected and the columns gave way between 15 and 25 minutes after the fire started.

Tall buildings as now constructed in our large cities act well as fire-stops. With the best construction they probably afford a very fair degree of protection to the occupants, but they are all vulnerable to the attack of fire from without, that is, to the external hazard. This latter condition was well exemplified in the fires which occurred in the Manhattan Savings Bank Building and in the Home Life Insurance Company's Building, in New York City (Fig. 18); in the Horne Dry Goods Store and the Horne Office Buildings in Pittsburgh (Fig. 19), and in the new tall buildings of so-called fireproof construction in the city of Baltimore (Fig. 20). All of these buildings were badly injured by fires originating in other structures.

A tall building is vulnerable to a fire without because the fire can enter through the windows on the different floors at the same time. When this condition happens it practically places the building beyond the help of the fire department until considerable destruction has been affected.

Tall buildings are also vulnerable to fire through floor openings and wells for elevators, stairways, etc. These openings from basement to roof form a flue through which the fire is rapidly drawn to every floor. The practice of cutting transom lights in the partition walls dividing the various departments is also a great fire hazard and permits a fire originating on one apartment to spread to the adjoining rooms. Many so-called fireproof tall buildings contain a very large percentage of weight in wooden construction. By careful planning much of this wood can be omitted or really non-combustible material substituted for it.

The question naturally arises whether or not it pays the owner to make a building fireproof. Unfortunately there are many who build for the specific object of obtaining the greatest income from a minimum outlay, and the effort to save on first cost is so great as to render their judgment valueless as to what should or should not de done. Tall buildings of cheap construction are a menace not only to owners and tenants but to the community.

Nearly every builder estimates the amount of space devoted to public use, and concludes that the best building is the one that has given up the least percentage. While this effort is commendable from a purely income-earning standpoint, it often renders the design dangerous to life and property, and frequently makes it impossible to design a building under conditions which can be classed as fireproof. As long as stairways and elevators are placed together in the same well there must always be a strong tendency to cut off escape as well as a menace of saving property from the floors above the place where the fire originates.

Owners do not hesitate to spend thousands of dollars on fancy marble panelling, architectural carving and similar ornamentation, and will refuse to spend a few hundred dollars to have plans prepared properly and to see that the dangerous parts are constructed with that care which a really fireproof building should demand.

Ira H. Woolson. I agree most heartily with Mr. Gilbreth's appeal for a really fireproof construction, though I am not prepared to endorse the refinements of concrete house molding which he advocates. I question also the feasibility of his scheme for a central manufacturing plant from which certified concrete is to be distributed about a town. That scheme might work where a whole new town were to to be built at one time, but for efficiency and economy it would be necessary that a plant of that character be in continuous operation, and I can not see how that could be accomplished with the ordinary irregular building activity of a city.

There is no material which compares for an instant with wood for utility, economy, and artistic effect for interior trim, but there is none so dangerous. Admitting these conditions, it is evident that everything should be done, that can be done consistently, to make our homes more safe. It is not necessary, however, that such houses be cast of concrete in order to make them fire-resisting, Many beautiful and comparatively cheap houses have been constructed of terra cotta tile, concrete tile and concrete building blocks. Such houses can be rendered strictly fireproof by combining incombustible trim with metal doors and window sashes, and if desired, a reasonable amount of wooden trim, treated to make it non-flammable, could be employed without serious danger.

Unfortunately we are more extravagant than any other people in our use of wood in building construction. The practice is a most pernicious one and, as pointed out in Mr. Gilbreth's paper, we are paying a tremendous price for our folly. But the gravity of the situation is being realized more and more, and statistics of fire losses gathered by the Government and underwriting organizations are being studied by thoughtful men throughout the land. Valuable papers are being published suggesting methods of stopping this terrific loss. It can not be stopped, however, until the public is made to understand the magnitude of the waste, and taught how it can be avoided. When the gravity of this danger from fire is fully understood and the fact that it can with certainty be very largely prevented by proper precautions, the reformation will be half accomplished. The demand for strictly fireproof buildings will become so insistent that other types of buildings will be unpopular and unprofitable.

Mr. Gilbreth discusses at some length the construction of a fireproof dwelling, but it is not clear to what type of dwelling he refers.

He seems to imply the ordinary two or three-story structure commonly known as a private house. A building of that kind can undoubtedly be made fireproof, but if designed to be artistic and handsome, it will necessarily be more expensive than if built of non-fireproof construction. As a general proposition, it is difficult to make a handsome house strictly fireproof and have it satisfy the artistic taste of the architect and owner. However, that type of dwelling is a very small minority in New York City, and aside from its limited number, I consider it the type that is least important to be made fireproof.

The restrictions of our building laws have so operated as to give us in this city three general types of dwellings: the private house, 2 to 4 stories high: the 4 to 6-story flat or apartment (usually non-fireproof); and the 10 to 12-story so-called fireproof apartments or apartment hotels.

In the manner of construction there is but little difference between the first two types. They have both either stone or brick walls, wooden joists, wooden partition studding, wooden lath, and any quantity of wooden trim. There is little attempt to make them fire-resisting, though the tenement house over four stories high must have the first floor made fireproof to hold back basement fires, and the hallways and stairs are to a certain extent fire-resisting.

The private house is usually better built, because constructed with less economy, but only the expensive ones are in any degree fireproof. However, the private house usually harbors but one family. They have large rooms, generous stairways, and only three or four floors. If a fire occurs, human life is seldom sacrificed. Hence my assertion that the fireproofing of this class of dwelling is the least important.

Looking at one of these tenement buildings in the course of erection, one is reminded of a tangled mass of tooth picks. From ground floor to roof there is a forest of 2 in. by 4 in. studding, supported by tiers of yellow pine or spruce floor beams, all of which are later boxed in by $\frac{7}{8}$-in. flooring, and plaster on wooden lath. The result is a 5 or 6-story brick box divided into a host of little rooms, closets, narrow halls and stairways. These little box-like rooms are filled to overflowing with tenants, and the whole structure is a fire-trap and a disgrace to the city. There are miles of such constructions, constituting a constant menace to our city's safety. Fires in them are of daily occurrence and loss of life is frequent. As a matter of fact, the loss of life at these fires is so common that the record in the daily papers scarcely causes comment. In the past 20 days there have been 40 good sized fires in 5 and 6-story tenements in the boroughs of Manhattan, Bronx and Brooklyn, and scores of small ones. Though no lives have actually been reported lost in that period, there have been a score of thrilling rescues and several persons were injured and burned.

Many of the tenements are filled with an ignorant, vicious class of foreign population, and numerous fires result from their carelessness. Among this class, also, a favorite revenge for fancied wrongs is to start a fire. A cup of kerosene or a few oily rags are all that is necessary to produce a lively blaze and instantly a hundred or more innocent people are in deadly peril. But this type of construction is by no means confined to the tenement districts. The cross streets and broad avenues of the best portions of our city are lined with them, and they are a constant source of worry to the fire department. If the two or three conditions which are necessary to start a conflagration ever occur simultaneously, we will have a fire horror in this city which would discount the records of Boston, Chicago, Baltimore and San Francisco. It is the worst of foolishness to continue such construction in a congested city like this. Must we have an awful lesson here before the practice is stopped?

The third class of dwellings is the 12-story apartment. The building laws of New York City permit one to build pretty nearly as one pleases as regards fireproofing, up to 6 stories; from 6 to 12 stories he must make the floors, partitions, elevator shafts and stairways fireproof, but he may still use unlimited wood for trim. Above 12 stories, if wooden trim is used it must be treated to make it non-flammable, otherwise metal trim, or wood covered with metal must be substituted. This last type of building is really very safe if honestly built. It is distinctly the office building type, the so-called skyscraper, but it also includes some of our large apartment houses and apartment hotels.

Buildings of this class are safe as regards destruction from an ordinary fire. At least they will hold the fire until firemen can prepare to combat it. They may justly be called fireproof. As a class they are being very satisfactorily built at the present time. In buildings of the 12-story type, if properly constructed, a fire ought to be confined to the apartment in which it started, so far as interior transmission is concerned. The great danger, however, is that the fire will travel from floor to floor by exterior transportation, that is, by way of the windows.

This is a serious menace to both life and property. Of course, very much greater security could be obtained by the use of wired glass windows, in metal sashes. It takes very little heat to break an ordinary plate-glass window pane, but wired glass in a metal frame will remain in place until it melts. There is objection to the use of wired glass in windows which are to be used for observation purposes, but I believe much protection could be obtained from the window exposure hazard, if the upper sash were required to be wired glass. This would not obstruct the view, nor injure the artistic effect of the room, but it would serve to confine the flames in the top of the room and when they did get out they would issue through the lower sash, some three or more feet below the top of the window. This increase of distance between the windows of the two floors, would materially lessen the danger of communicating a fire to a floor above.

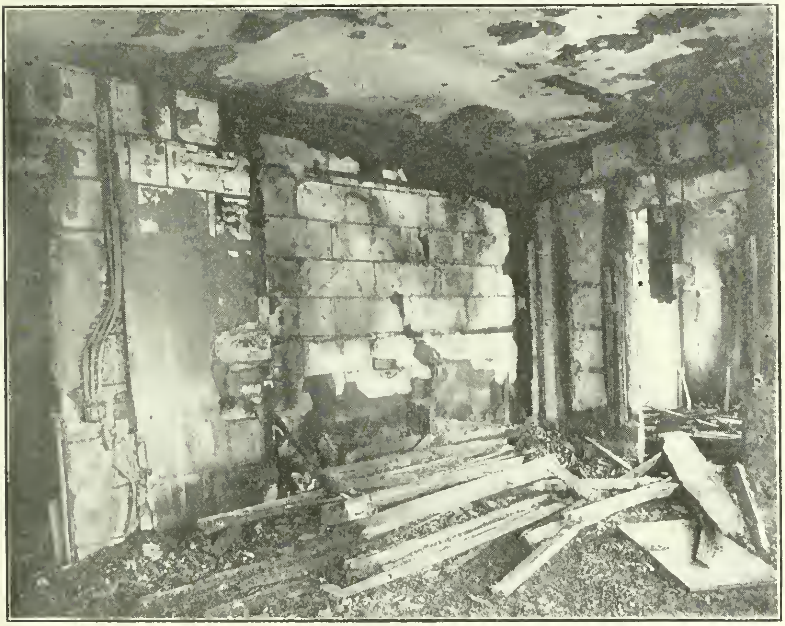

Fig. 21 One of the Dining Rooms after the Fire

As the floor was unoccupied, the only thing to burn in this "fireproof" (?) room was the trim.

The quantity of lumber used for trim and decoration in the 12-story so-called fireproof apartments is astonishsing. Figs. 21 to 24 illustrate the perniciousness of this practice. They were taken after a fire a few months ago in an extremely handsome apartment house in the upper part of New York City. There were literally wagon loads of highly inflammable wooden trim used in each apartment, and this produced a terrific blaze, which shot out of the windows and into the windows of the floor above, where the same thing was repeated. Four apartments vertically over each other were thus burned out by the flames jumping from window to window. Although there were apartments on each side of these which burned, no transmission of fire occurred on the interior. Had the trim in this building been non-flammable, as it most certainly should be in a building of such pretensions, it is very probable the fire could not have escaped beyond the apartment in which it started.

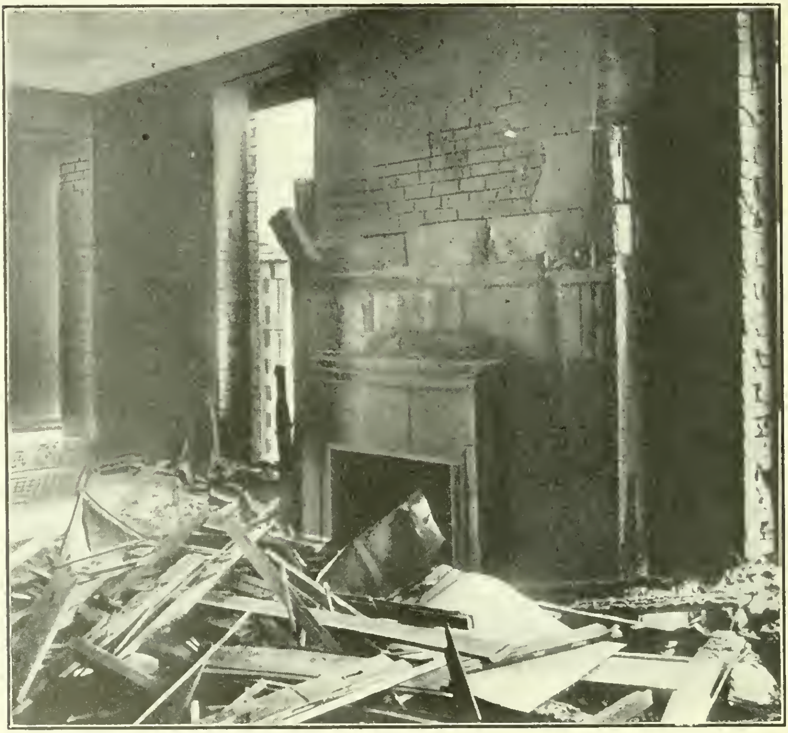

Fig. 22 View of Another Dining Room
Note the trim still unburned.

As an evidence of the ridiculous laxity of our existing building laws as regards the freedom with which a literal bonfire structure may be erected in this city, Figs. 25 and 26 are reproduced from photographs taken of a building now in course of erection upon one of our most exclusive avenues and on one of the busiest corners in the city. This structure is possible because it is only 75 ft. high. It is colossal folly to permit such construction upon one of the most prominent sites in the city, surrounded by handsome buildings of the older non-fireproof type and many others more modern, which cost millions of dollars.

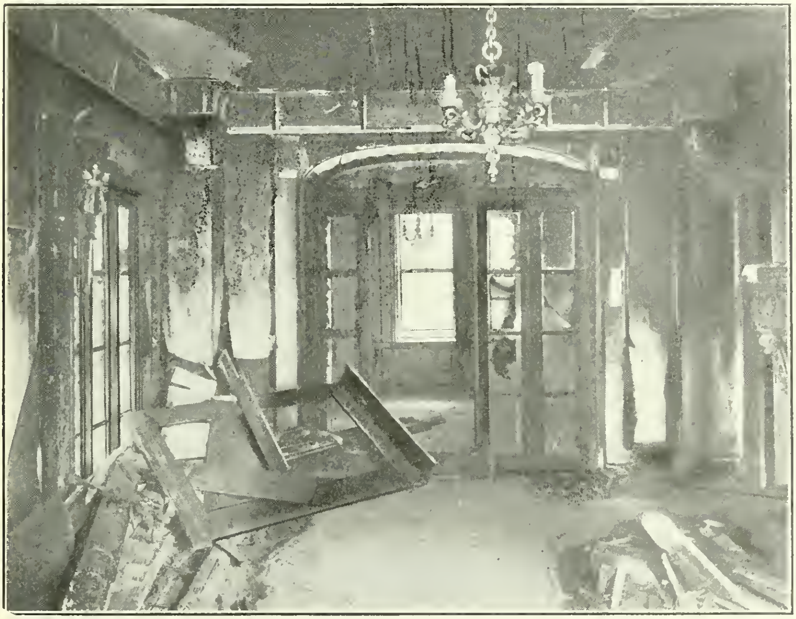

Fig. 23 Reception Hall Just Off the Dining Room

Note the light wooden doors glazed with thin glass and the amount of wooden trim.

The extravagant use of wooden trim shown in Fig. 27 is by no means an isolated instance. The majority of our apartment houses under 13 stories in height are liberally trimmed with wood, though not often to the excess of the one just described. I took occasion recently to have an experienced estimator from a lumber yard go to an apartment up town and carefully measure the wood used in finishing the sitting room and dining room. The building is new and called fireproof, but we were astonished to learn that those two rooms contained the equivalent of over 1700 sq. ft. of soft, highly inflammable wood. Much of it was white wood well covered with paint which would add to its natural combustibility. This estimate included the door and window bucks, the double flooring and the sleepers which were set in the concrete floor beneath. From this as a basis it was estimated that the whole apartment contained about 4000 ft. and the entire 10-story building would total 160,000 ft. equivalent to eight carloads of kiln-dried, painted and varnished kindling wood. Add to this the

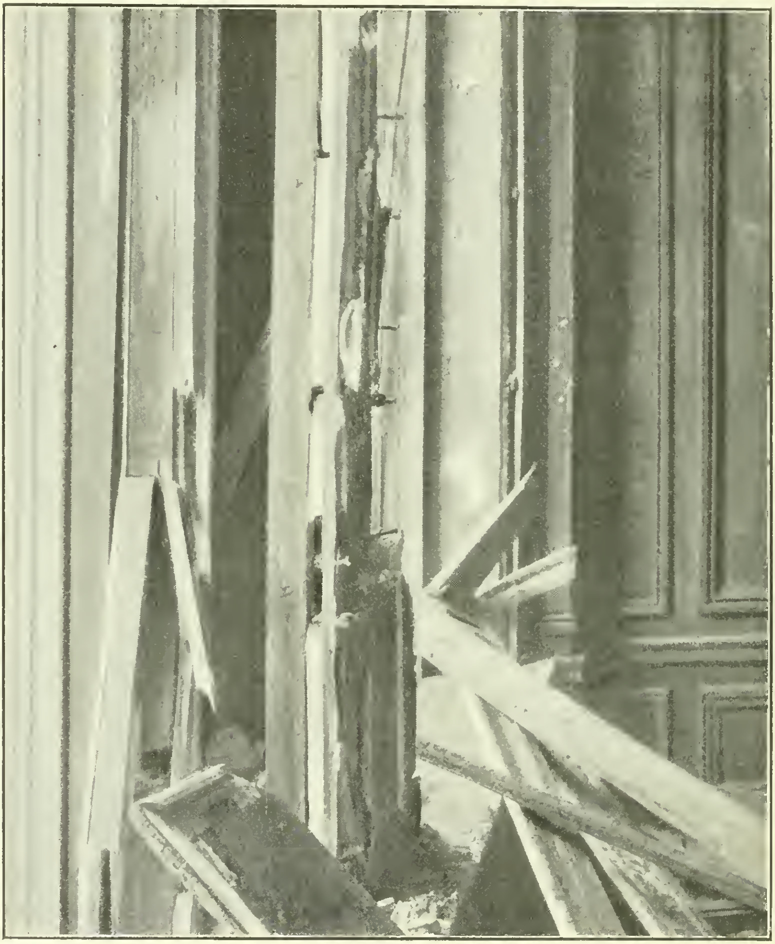

Fig. 24 Wooden Studding and Trim used Around Windows
Note concealed air spaces which are known to be very dangerous in case of fire.

furniture and furnishings of each room, and you have the material for a big blaze. Would it be surprising if such a fireproof building were to be completely ruined by a fire? There would be instead cause for astonishment if any considerable portion of it escaped.

This building is no exception in its class. There are hundreds of others like it, and while the fireproof partitions and hallways will usually prevent a fire spreading laterally, there is always grave danger of its traveling upward by way of the windows, dumb-waiter and air shafts. This type of building would offer very little resistance to a conflagration. Blasts of hot air from nearby burning buildings would ignite the window frames and break the glass on a whole front at once. Under such conditions its complete destruction would be certain. Whether the occupancy were domestic or commercial in character, the buildings would burn with equal fierceness.

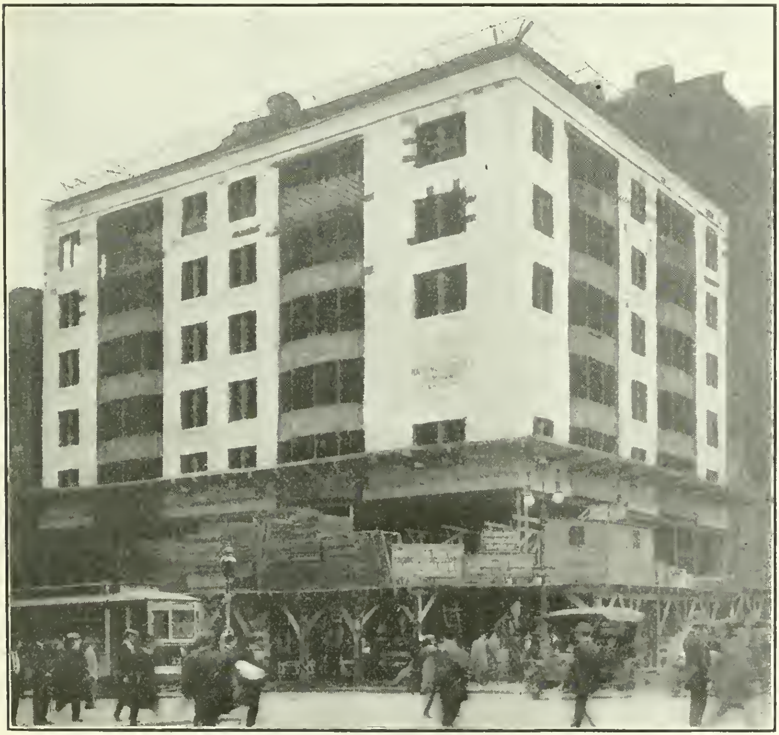

FIG. 25 BUILDING AT FIFTH AVE. AND 42D ST.
This building is filled with wooden construction.

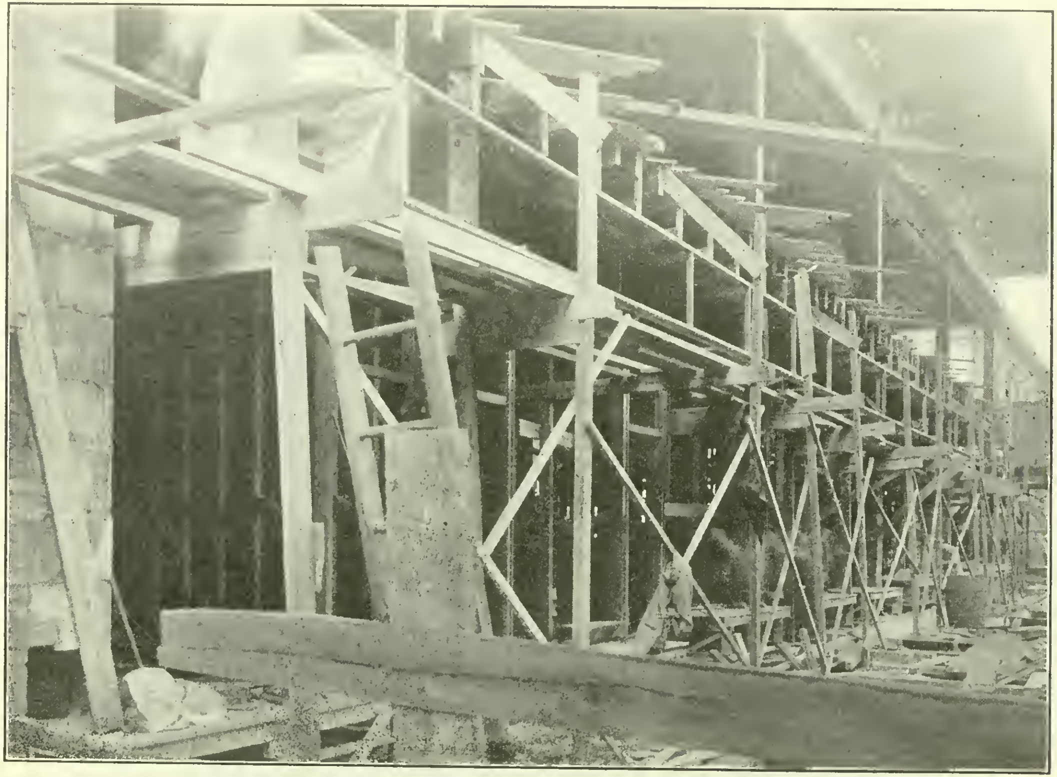

FIG. 26 VIEW OF SAME BUILDING LOOKING THROUGH FROM 42D ST. TO FIFTH AVE. ON THE GROUND FLOOR

The 2 in. by 4 in. wooden studding is so thick that all the light is cut off except a few spots

The dwellers in these 10 and 12-story structures must be taught the danger which surrounds them. They must understand that they are not exempt from fire hazard because they are housed in a building with fireproof floors and partitions and protected hallways. Fill it full of combustible trim and furniture and you have a great stove with air shafts, elevator shafts, and dumbwaiter shafts for flues, and windows acting for either draft openings or flues, depending upon circumstances. These are excellent conditions for a vigorous fire. There is strong probability that a fire well started on the sixth or seventh floor of such a building would go to the roof and sweep all before it.

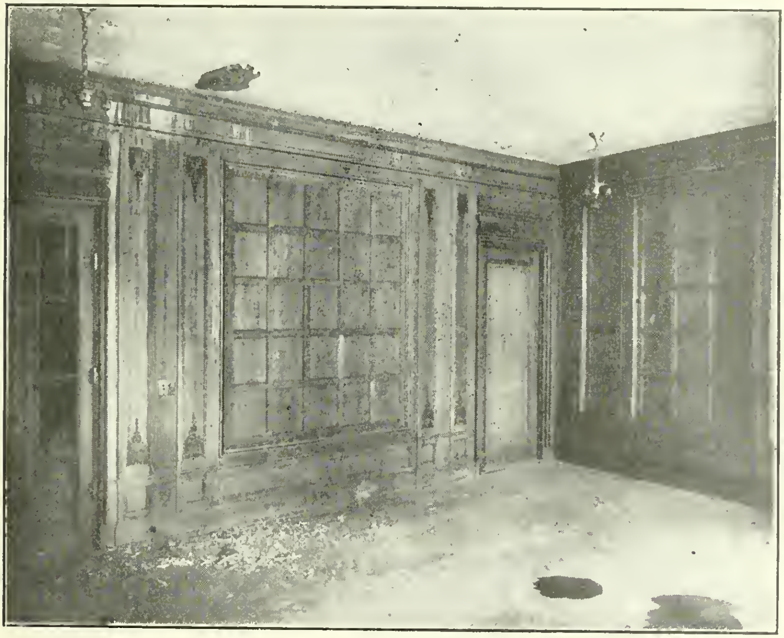

Fig. 27 Dining Room on Floor Below where Fire Occurred

The efficiency of the fire department is greatly lessened at that height. Streams of water thrown from the street have little effect, and even a water tower is of doubtful utility above the ninth floor. Firemen must make their fight from the interior of the building, or from fire escapes, with water supplied by a standpipe in the building. If it should fail the situation would be well-nigh hopeless.

The custom of building such structures for dwellings and commercial purposes should cease. It is not in harmony with our boasted civilization and much-vaunted scientific progress. Take a fire like that which recently occurred in a lumber yard on West 24th Street and ruined half a block before it was checked. It needs a very slight tension on ones imagination to picture what would have happened had that fire occurred during a high western wind. Under such conditions it might very easily have escaped from the control of the fire department and plowed its way across the city, a roaring mass of devastating horror. In front of it were miles of buildings similar in character to those described, and they would have gone down before it the same as similar buildings vanished before the conflagrations in Baltimore, Toronto, San Francisco and elsewhere.

Think what such a conflagration would mean in a city like New York, with its enormously congested population and financial values. The result would be appalling. If such a conflagration were to sweep some sections of our city the money losses would be staggering. The credit of the city might be ruined, and the financial system of the country shaken. This is no extravagant vision of an alarmist. It is a real potential possibility, and it is high time we began to limit this hazard by insisting that all high buildings be fireproof in fact as well as in name, and that all buildings over two stories high shall have fireproof floors, partitions and hallways.

I fear this will never be accomplished by appealing to the public spirit of the speculative builder. He is building to sell, and the cheapest, flimsiest construction that the law will allow is the one he will adopt. Building laws must be enacted which will prohibit the erection of inflammable structures within our congested areas, and then we must insist upon a strict enforcement of the same. Such laws will not be enacted until citizens appreciate their necessity and demand that their representatives decree them.

P. H. Bevier.[1] The writer would like to discuss this able paper along the line that under certain conditions other fireproofing materials than concrete are equal to or better than this much praised and abused material.

To call the Mutual Life Insurance Building of San Francisco a typical building and proceed to argue that hollow tile was a failure and therefore all fireproofing of hollow tile is worthless is most unfair when scores of buildings have been subjected to fire which completely destroyed the interior and yet left the hollow tile floor arches practically intact. It is impossible for any one to say just how much of the damage to any of the buildings in San Francisco was done by fire and how much by the earthquake, but it is fair to assume that many thin partitions of hollow tile were thrown down by the shocks.

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[1] Supt. of Construction, National Fire Proofing Co., New York.

Mr. A. L. A. Himmelwright, member Am.Soc.C.E., in his report on the Mutual Life building for the Roebling Construction Company said:

> The floor arches are in fair condition. There are many places where the soffits of the tile blocks have fallen away, exposing the cellular spaces. The partitions are badly damaged throughout, a large proportion of the blocks having fallen down. Safes also caused the failure of some of the floor arches in this building. The column protection having been set independently of the partitions, is in fairly good condition. Some of it has been forced away by bulging pipes but the columns are apparently uninjured. The fireproof floors are 9-in. end construction hollow tile flat arch blocks with skewbacks of side construction. The shells and webs are $\frac{5}{8}$ in. and $\frac{1}{2}$ in. thick respectively. The partitions are of hollow tile blocks. The column protection is of 3-in. hollow tile blocks. Comments: This building exemplifies very forcibly the necessity of protecting large trusses in an efficient manner. The protection should consist of some material which will remain in place and which can be rigidly anchored to the structural members. The failure of the fireproof protection of the trusses is no doubt responsible for the entire damage to the two upper stories of the building.

We see from the foregoing report that the Mutual Life building was not an example of first-class hollow tile fireproof construction. In the first place the arches should have been at least 12 in. deep for the spans used instead of 9 in. and the shells and webs should have been $\frac{3}{4}$ in. and $\frac{5}{8}$ in. instead of $\frac{5}{8}$ in. and $\frac{1}{2}$ in. and of semi-porous instead of dense material. The partitions should have been not less than 4 in. on all floors except the first which should have been 6 in. The members of the trusses should have been fireproofed with porous material 2 in. thick applied and anchored securely to the steel.

It is a well-known fact that many other buildings of hollow tile fireproofing in San Francisco were repaired at very little expense and were occupied within a few days after the fire. This was true of the Union Trust Building, as to floor arches; the Mills Building, which cost about 5 per cent of the original cost to repair arches; the Flood Building and others not so well known.

The author states that no structure of the future should contain any wood. This is good doctrine and is attainable. Had the

Mutual Building contained no wood, there would have been little damage except from the earthquake, whether it had been built of stone, brick, hollow tile or concrete, but with all the advantages of beauty and quick construction in favor of steel frame, brick and terra cotta exterior with hollow tile fireproofing.

. "With metal forms and certified concrete, concrete construction is cheaper today than brick, hollow terra cotta tile or any other material." This has been the dream of Mr. Edison for many years but we do not see many poured houses. Progress along this line will undoubtedly be made for factory building construction, for farm buildings and where rigid economy at the expense of all attempt at ornamentation is imperative. There has not to my knowledge been produced a system of metal forms which can be used to meet the varying conditions of floor arch construction at a less cost than for wood centering.

There may be yet some factory owners who would pour a group of houses for his employees from one set of molds but that day is rapidly passing for "The Town Beautiful" is an accomplished fact and ugliness for the sake of cheapness will not be tolerated. No individual owner who is able to employ an architect would accept a stock design for his building.

Flat ceilings are most desirable. This can be best accomplished, not by solid slabs of concrete, but by a combination of hollow tiles and reinforced ribs of concrete. For equal strength this type is the lightest and cheapest and most generally used.

"Metal moulds have reduced the price of concrete to that of wooden construction." This may be done in the future but it will probably be done only when wood is dearer than at present and when the design of the building is made to fit the forms rather than the forms made to fit various designs of buildings.

"Concrete hauled in large quantities from a centrally located factory and poured at once for the entire story of a building." Where has this been done?

"A concrete building is cooler in summer and warmer in winter than any other kind. It is drier than any other provided it is built with self-ventilating air spaces in all exterior walls." A solid concrete wall is cold and damp at all times unless the walls are furred. If built with hollow walls it is very expensive. A house built of hollow tile blocks with cement stucco on the exterior is the ideal house for what is above claimed for the concrete house and is very much cheaper and more artistic.

I object to the statement that concrete is the only rival to wood in low cost. This can be proved erroneous in view of the fact that hollow clay tile under many conditions is cheaper than concrete. Competitive bids on reinforced concrete and steel frame with hollow tile for the same building have frequently been made and generally in favor of the latter construction when the building is more than four stories high and time of completion is an element in the proposition.

The claim that concrete walls can be poured in metal molds with sufficient accuracy to permit of painting and wall-papering without plastering or smoothing, is another dream of the enthusiast which has not yet come to pass. Warehouses and factories may have their walls and ceilings white washed and let it go at that, but dwellings and office buildings, schools and institutions to be inhabited by people require a better finish than it is possible to make by any known method except at a cost much greater than plastering.

As to the damage by fire in concrete buildings, the pamphlet "Trial by Fire at San Francisco, the Evidence of the Camera"[1] proves that reinforced concrete suffered even more from fire than hollow tile but less from earthquake. I thoroughly agree with Mr. Gilbreth's arguments that fireproof construction should be exclusively employed and the use of wood, as far as possible, abandoned.

Each building proposition should be considered as a separate problem and the best solution sought. When concrete material is convenient and cheap, the building plain and rectangular for factory or warehouse purposes and not too high, and there is no great hurry for its completion, then possibly concrete may be used to advantage.

In the city where all the conditions are different, then the steel frame constuction with brick curtain walls with tile arches and hollow tile partitions is best and cheapest. Country and suburban houses can be best constructed of hollow tile, interior partitions of hollow tile, floors of combination arches of hollow tile and reinforced concrete, cellar walls of concrete.

Charles T. Main. Mr. Gilbreth notes that the United States is paying a preventable loss of more than $366,000,000 annually, this being the difference between European losses and those in our own country. The estimated cost of private fire protection, including capital invested in construction and equipment, is $50,000,000 with an interest account and watchmen's cost amounting to $18,000,000 more. It does not seem possible to omit very much of the public fire-fighting apparatus and systems or the private investment, for this purpose, even if every building were proof against destruction by fire inside and outside, because the combustible contents of city buildings and factories make it necessary to put in hydrants, sprinkler and pumping systems and to maintain fire departments in the same manner as they are now installed and maintained. The spreading of fire would be reduced and the losses decreased accordingly.

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[1] Published by the National Fire Proofing Co. Now out of print

In textile mills the value of the buildings is not more than one-quarter of the total value of the property, and the value of the property and of the stock in process is also a very considerable amount. In some of the rooms in a cotton mill the stock in process is very inflammable, and a fire will start from a spark or a heated bearing on a machine and go from one end to the other almost like a flash of gun powder. The insurance companies therefore require, even in fireproof buildings, a system of fire protection of the same capacity and efficiency as is required in buildings of slow-burning construction. As the losses on the contents of the buildings form a large part of our fire losses, it would be well to look for better regulations in regard to the storage of combustibles in our city buildings, including the retail stores.

In regard to the statement that fireproof buildings can be built as cheaply as those of the slow-burning type, I would say that in competition for a mill building recently, I obtained prices showing the cost of the concrete building to be about 25 per cent more than for regular mill construction. This is probably due to the fact that the floor loads in textile mill work are comparatively light.

In regard to the statement that if a whole floor can be poured at one time engineers can figure the textile strength of concrete when designing, I understand it to be meant that that portion of the concrete below the neutral axis down to the rods can be figured for tension. Investigations in this country have generally shown that when a beam is loaded much in excess of its ordinary working load, the concrete below the neutral axis cracks. As the assumed working load limits may often be exceeded, especially in factories, such cracking might occur, and then the beam would not have the tension factor which it was designed to have. Test loads would almost always destroy the tensile strength of concrete below the neutral axis, and many other conditions which will occur in the best actual construction will also help to destroy it. It has been my experience that concrete cannot be made with sufficient scientific accuracy in the field, and voids, cracks, etc., will sometimes occur.

It is claimed that with the use of metal forms, mechanical handling and placing concrete, satisfactory work and good appearance can be obtained by omitting all wooden trim, casings, etc. This claim is far in advance of the work which most of the contractors have been able to produce. Most of them are wholly unable to come anywhere near to what would be termed certified concrete.

Any educational work which the Government could do for the people along the line of fireproofing buildings and houses would be eminently proper and useful, but it does not seem as if the Government could place any taxes or restrictions on the use of wood or other materials which enter into the construction, since the supply of materials and knowledge of workmen is so varied in different parts of the country. If any legal steps were to be taken along this line, they should be taken by the separate States instead of by the Federal Government, and even then the conditions are so varied in a single state that it would be impossible to cover all cases.

Every engineer and business man should be in sympathy with most of the statements regarding the reduced cost of construction of fireproof buildings and improved quality of workmanship made in the press, and should hope that some day they may become common practice.

E. E. SEYFERT.[1] That no structure of the future should be built of wood and no structure of the future should contain wood is a conclusion which undoubtedly represents the means of preventing the enormous annual loss of property and life through destruction by fires. The fulfilment of such conditions will reduce the immense annual outlay of funds for fire protection and will be the means of solving the problem of conservation, as applied to the use of the metals and timber as materials for general building construction and engineering work.

The incombustible material which shall replace wood in building construction, is generally conceded to be concrete, a material capable of resisting high temperatures for longer periods, without injury, than brick, stone, metal or wood. It is obtainable everywhere at low cost and the labor necessary for its use in construction is of less cost than for any other building material. Concrete reinforced with metal is without limitations as applied to engineering structures. The combination of these two materials has established the ideal building material, as determined by its phenomenal development, both as to the amount built in each successive year and as to the variety of applications.

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[1] Chief Engineer, Pittsburgh Steel Products Co., Pittsburgh, Pa.

The theory concerning the mode of action of the two materials involved in reinforced concrete has constantly undergone modification, perfecting itself through deductions from experiments. The theory of such action at the present time is well established. As a matter of fact, more is actually known about the carrying capacity or the ultimate resistance of concrete steel members than about the carrying capacity of similar structural steel members. A great mass of well-considered and well-digested experimental data has been accumulated from full-size tests of both concrete steel beams and columns, perfecting the knowledge of their design and construction. On the other hand, no tests of full-size columns of structural steel exist from which it is possible to obtain data governing even the fundamental principles of design. Is it not, therefore, reasonable to assume that more confidence should attach itself to the consideration of the ultimate capacities of concrete steel members, beams and columns, of scientific design, as determined from actual tests, than to the computed ultimate carrying capacity of steel columns without determining experimental data.

It has for a long time been a recognized fact that to obtain reliable results, combined with efficiency and economy, in reinforced concrete construction, there must exist rational design, good cement, steel of standard specification, intelligent and effective handling and good inspection. These factors have not at all times been employed in construction. Accordingly the tendency of the profession has been in the direction of standardization of each element, a standard specification governing the quality of the material of each and method of its use. There has been placed upon the market recently a standard reinforcing unit frame, scientifically designed and standardized. It provides the depth of slab, beam or girder, designates the required unit frame, for any given load from 40 lb. to 600 lb. per sq. ft. of floor surface and for spans of beams or girders varying from 6 ft. to 30 ft. Columns, footings, rectangular beams and T-beams are standardized. The condition no longer exists, as Mr. Gilbreth pertinently remarks relative to the early development of reinforced concrete.

The materials of the present day which enter into the construction of reinforced concrete work are generally reliable. The ultimate success, however, of this class of work is almost exclusively dependent upon the proper placement of the metal reinforcement, provision for shear or diagonal tension by a system of rigid web reinforcement, careful handling, competent superintendence and rigid inspection.

It is almost a presumption to call the attention of engineers to the danger of the displacement of reinforcement in concrete work. Concisely stated, if the displacement is upward, there is a loss of strength proportionate to the amount of such displacement; if the displacement is downward, the fire-resisting qualities of the concrete are vitally impaired; also with reinforcement too close to the surface the dangers from electrolysis arises. It is the opinion of the writer, however, established upon experience, that it is necessary to call the attention of engineers to the necessity of making provision for the prevention of such displacement. It has become a fact that no matter how carefully separate bars or loose rods are placed in the forms, or what precaution is taken in the pouring of the cement, there can be no definite assurance when the work is conpleted that the metal is either in the proper position or in the quantity called for by the specifications. Cases have been actually observed, even with the most perfectly organized forces, where a rod or two have been accidently omitted from an important member, or where a short one has been thrown into the work to take the place of a lost longer one. The only certain method of overcoming this difficulty is by the use of a reinforcement fabricated in units and the application of such unit reinforcement should become compulsory.

The subject of shear or diagonal tension in beams and girders should be given greater attention by engineers. If it is unsafe to count on the tensile strength of concrete to resist horizontal tension, it is equally unsafe to count on it for diagonal tension, or for shearing stresses in the web. Diagonal tension failures are the greatest dangers to be feared in this class of work. In practice nearly every beam failure is of this kind. Many empirical systems have been produced, consisting of units composed of loose rods with wire stirrups, loose and unsupported bars with sheared edges and others in which no provision has been made for slip of web member other than the adhesion of the concrete. The fact that these systems have produced buildings which have not collapsed under load is no proof of the adequacy of their reinforcement. It is perfectly obvious that the formation of cavities in concrete will take place and that such formations are very nearly impossible to guard against during the operation of pouring and tamping of concrete in complicated units of loose bars wired in many directions. The solution of the problem is achieved, as determined from recent tests, by placing all web members at an angle of 45 deg. to the horizontal, and rigidly connecting them to a top horizontal bar and to the bottom horizontal tension member, thereby absolutely fixing them in position and eliminating all tendency to slip when in stress under the action of load or shock.

C. A. P. Turner.[1] As regards cost, Mr. Gilbreth is correct in his statement that reinforced concrete in the central and eastern sections of the country, economically designed, is fully as cheap as first-class timber mill construction where the floor capacity is 200 lb. per sq. ft. with column spacing about 20-ft. centers. Where the capacity required is less than 200 lb. per sq. ft., light timber construction will cost slightly less, but the difference in general is too small to warrant the risk for the majority of commercial purposes.

Many engineers are inclined to question the fire-resisting properties of concrete when made of suitable aggregate. Take for example the heat of the acetylene-oxygen blowpipe, something like 6500 deg. This would cause the ordinary piece of burned clay to crack, but turned on a 3-in. block of good gravel concrete has little more effect than the production of a minute puddle of molten glass directly under the point of the flame, which as soon as the flame is removed cools and sticks to the portion of the concrete so treated. The action of concrete under such high temperatures will naturally vary with the character of the aggregate. Where it is silicious in character, comparatively little damage will be done by long continued high temperatures; where of granite, splitting and spalling may occur; where of limestone, some of the limestone may be injured by the extreme heat, though this process is extremely slow.

One of the greatest causes of injury to the building made up of incombustible materials during a conflagration is the unequal expansion and contraction of the materials entering into the make-up of the building. For example, with steel beams and hollow tile fireproofing, the steel and tile do not expand and contract at the same rate. The result is frequently shattering of the hollow tile, leaving the so-called fireproof floor in a dangerous condition.

With reinforced concrete the effect may be, where thin beams or ribs are used, to dehydrate or damage the projecting ribs where a part of the construction may be overheated without correspondingly overheating the main portion of the floor. Where, however, the floor is of a thick plane flat slab of reinforced concrete the effect of the high temperatures and subsequent chilling by turning on the hose is comparatively slight.

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[1] Cons. Engr., 816 Phœnix Bldg., Minneapolis, Minn.

A fire test was conducted in Denver, in which two loads of pine wood split into faggots about 2 in. sq. and drenched with oil were used. A very intense heat was secured within 5 ft. of the under side of the slab, which was heated in the course of a half hour practically to a white heat. The hose was then turned on and the fire extinguished. No material damage resulted to the slab in the case of two tests when it was loaded to more than twice its normal working load, the spans being approximately 20 ft. A third test was made on the concrete in a partially cured state. The aggregate in this instance was a sandstone metamorphosed almost to a quartzite, but containing veins where the material was porous. The slab in this instance not having thoroughly cured, steam was generated in these veins and caused the rock to pop or explode with a noise like a pistol shot, breaking or spalling out to a depth of about 1 in. under the surface of the slab over an area of about 2½ ft. in diameter. The fire in this case was very intense, but the carrying capacity of the slab was practically uninjured, although some permanent set resulted, due to the elongation of the steel under heat. This permanent set was in the neighborhood of ⅜ in. in 20 ft. Duplication of this test on an adjacent panel after the concrete had been given ample time to cure resulted in no damage whatever. Test of the quartzite in an assayer's furnace showed that it could be heated to a white heat and then quenched in cold water without injury, while smelter slag, granite and gravel samples, subject to the same treatment were reduced to powder.

It is evident that a fire test like this may be considered fully equal to anything which would ordinarily occur in a fireproof building. The damage to the building would be practically nil and the real need for insurance is more to protect the contents of a properly constructed concrete building than to protect the building itself.

The writer regrets to note that there is a tendency among insurance companies to discriminate against concrete in favor of inferior types of fireproof and even combustible construction. For example, the ordinary mill building with a sprinkler system is rated on almost the same basis as the concrete building. Why any building of this construction, which will make the hottest fire when once started, should receive the benefit of rates lower than one which is practically impossible to burn is rather hard to understand. The owner of a concrete building is well aware that his building is practically indestructible and while it may be damaged by smoke and the contents be lost, he is satisfied that he will not lose the building and declines to pay an unreasonable rate of insurance.

Going further into the matter of cost, the writer has long advocated the simplification of the centering and use of flat floor construction as being most economical, most readily erected and the most satisfactory from the fireproof standpoint. Where, however, the building is low, the loads, such as roof loads, are light, and the spans long, it is possible to put up independent beam construction with light roof slabs cast separately and erected in place without forms at a lower cost than it is possible to build of monolithic construction. This type of construction has been utilized for car shops and the like in many parts of the country with success.

Some of the advantages of reinforced concrete from the fireproof standpoint are not apparently well appreciated. As the concrete gets older and harder its fire-resisting properties increase. Poor mixtures, lean concrete and bad work do not make a first-class fireproof building in reinforced concrete any more than a poor mixture, insufficient thickness, lack of proper ties, render concrete a suitable fireproofing for structural steel frame. It is an unfortunate fact that many of the structural steel frames encased in concrete are by no means fireproof.

Some months ago the writer, while visiting the city of Denver, noted a 12-story building in which so-called concrete fireproofing was used. The architect had adopted a full structural steel frame, believing that reinforced concrete was not reliable from the standpoint of strength, yet he had sufficient faith in concrete as a fireproof material to adopt a thickness of casing around the structural steel column barely thick enough to cover the rivet heads. This was on a plate approximately 18 in. wide. Such fireproofing, even though it be of concrete, can hardly be regarded as other than a joke and the sooner insurance companies adjust their rates to correspond with the risk, the better it will be for them from a business standpoint.

To those in the central and western portions of the United States it seems to be a fact that eastern cities, particularly New York City, are decidedly backward about adopting up-to-date methods of fireproof construction. This statement is based in the building regulations of the cities in question and it is seemingly having an unjust influence, perhaps, in the judgment of the members of the engineering and architectural professions in the cities where such rules are in vogue. The tendency of the investor, after seeing the success under more liberal codes, is to conclude that the professional architects and engineers located in cities presenting unreasonable requirements are responsible therefor and the tendency is for the investor to lose confidence in the professional talent of the locality in question. He argues, with some degree of justice, that unreasonable ordinances would not be in force were they not supported by the more influential representatives of the engineering and architectural professions of the city in which they are in vogue.

George G. Hopkins, Jr. Some of the pictures shown illustrated many of the common defects in fireproof construction, the chief of which were lack of protection at window openings and inadequate protection of floor openings. It is perfectly possible, by protecting all door and window openings, including those in courts, by tin-clad wood fire shutters, by corrugated iron shutters made on standard angle iron frames or by wired glass in hollow sash windows, to prevent an outside fire entering a building. A group of such buildings would furnish the best stop to any conflagration. If the fireproof buildings in Baltimore had all their window openings protected they would doubtless have escaped and done much to check the flames. Of course the advantage of protecting exterior openings is not confined to fireproof buildings.

The protection of the floor openings, stairs, elevators, etc., is of the greatest importance, and the general principle to be borne in mind is to make the enclosure of all floor openings equal to the floors. A chain is no stronger than its weakest link. So it is little use to build partitions of terra cotta blocks and then put in thin glass transoms and sidelights. It is equally useless to build an elevator shaft and use crimped iron doors on light flat iron frame that will warp out of shape the minute a fire touches them. It is just as bad to put tin-clad fire doors on a wooden stair enclosure. Stairs and elevators can easily be inclosed by brick shafts with underwriters' standard tin-clad fire doors at the openings to the floors. With the best modern practice favoring electrical power transmission, belt holes can be entirely eliminated or a vertical power shaft made to pass through close-fitting bearings in the floors can be provided.

DISCUSSION AT ST. LOUIS

E. D. Meier said that the difference in climate and in the habits of the people here and abroad has important bearings on the question of fire loss and fireproof construction. In this country great quantities of inflammable material, such as hand bills, theater programs, boxes of matches, etc., are given away quite freely and as a consequence, our streets are littered with this material. Then our climate is much drier than that of the European countries with which comparison is made. When these conditions are combined with the careless habits of smokers who drop unburned matches in public places, the danger from fire may readily be seen. In Europe such material is not given away so freely; everything, whether it be a theater program or a box of matches, has a definite value and is not thrown carelessly about in public places, considerably reducing the quantity of inflammable material.

He further said that he did not believe in buildings erected without inflammable material nor in those built largely of wood, but preferred a middle course, such as wooden doors enclosed in steel or copper sheathing; neither did he believe concrete window sashes to be practical.

He said he was a great believer in concrete, but in a building containing a large quantity of inflammable material such as a library, an office building or a dry-goods store, no matter how well it may be constructed, he did not consider it safe without a sprinkler system in addition. Probably the best construction would combine a concrete building with the sprinkler system.

James Waterworth.[1] I agree with Col. Meier in that the difference in climate and in the temperament of the people, as well as in the type of construction, make deductions drawn from the experiences in Europe and in this country comparatively valueless. One of the largest dry-goods companies in St. Louis, operating a very large store with inflammable construction and contents, was paying 2 per cent a year for insurance, making their annual premium $10,000. An even larger store in Glasgow was obtaining the same amount of insurance for $700. This great difference is due partly to the climatic conditions, which leave the wood and other materials in the building not so susceptible to immediate ignition as in this climate, where wood is dried to a condition permitting rapid combustion, and partly to the difference in the habits and temperament of the people. For these reasons it will hardly be possible to obtain in America by means of any form of favorable construction or protection results that similar construction would secure in Europe.

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[1] 523 Odd Fellows Bldg., St. Louis, Mo.

It is hard to convince an insurance man that any building is fireproof and I question whether any mercantile building containing large stocks of dry goods can be made fireproof without destroying the mercantile features of the building. It may be possible to construct a fireproof building in which the material can be consumed without damage to the building, but it then ceases to be a place suitable for the display of goods.

Many of the new buildings in St. Louis have steel skeleton frames protected with tile and have tile floors. I do not consider that the best fireproof construction for a building containing a great quantity of fuel in the shape of merchandise. We have reached the concrete stage and have a very notable example of that construction in the Butler Building and we recognize its fitness. This building, covering the entire block, eight stories high on one side and seven stories on the other, would carry an extremely high insurance rate except for its reinforced concrete construction. The insurance on the building has been placed at the rate of 9 cents per $100 per annum on account of its fireproof qualities of construction. That is the response of insurance to the new concrete construction.

I regret to say that a factory is soon to be built in St. Louis of mill construction in preference to concrete. This seems to bear out the statement that concrete construction is not yet so cheap as mill construction or that the rules governing the construction of concrete buildings are too exacting.

It is true that a building of mill construction properly equipped with automatic sprinklers gets a better insurance rate than a concrete building not so equipped. Experience has shown that the average loss ratio of buildings equipped with automatic sprinklers is less throughout the United States than that of fireproof buildings not so equipped. The use of good concrete construction in an office building would make it practically fireproof were it not for the fact that every such building contains a great funnel formed by the stairway and elevator shaft from top to bottom of the building. No building can be considered fireproof where there is free communication between the floors through which the fire can travel. Under these conditions even a fireproof office building may be destroyed or nearly so by the combustion of the furniture and papers it contains.

The word fireproof is a relative term and must always be so used. I doubt very much if a building like the Ely Walker dry-goods store, containing 30,000 sq. ft. of floor space open from end to end and entirely filled with merchandise, can be made absolutely fireproof, and question whether any building ever constructed for mercantile purposes would stand the combustion of its contents without great damage to the structure. But we can have fireproof dwellings and apartment houses if we choose to build them properly. I believe there is no doubt that concrete is the coming building material.

A. B. Greensfelder[1] said that one of the most amazing things to the constructor is the fact that the Fire Prevention and Insurance Bureaus are seldom consulted regarding the details of the construction before a building is erected. The usual procedure is to go to the Insurance Bureau after the building has been completed and ask for an insurance rate. When an inspection of the building shows the errors committed from an insurance point of view, changes are necessary to meet the insurance requirements. It would be much more economical to submit the plans to the Insurance Bureau or Fire Prevention Bureau for approval before the work is started.

He thought the vital difficulty with reinforced concrete construction is that we do not think in terms of concrete, but rather in terms of the more familiar materials such as structural steel, brick and timber, making our concrete conform to the construction required by these other materials. It will probably be in the next generation that concrete will be considered as a material by itself, and when that stage is reached marvelous results may be expected.

The construction of the present day is very crude. For instance, in erecting a reinforced concrete building, wooden floors are frequently employed which can never be considered fireproof although certain measures can be taken to make them fire resisting. Unit construction is now being developed, but has not yet been widely employed. Very little has been done to embellish concrete buildings, especially regarding the use of colors. In the city of Havana, Cuba, white buildings are prohibited on account of the effect of the reflection of light from the walls of such buildings. As a result, all the buildings employing stucco-concrete are in colors. Local conditions make this a cheap construction and the color scheme is very good.

Reinforced concrete has served a good purpose in bringing engineers into building construction, resulting in a greater amount of scientific study along these lines, but some of them are too optimistic about the possibilities of concrete. In the papers of ten or fifteen years ago we find the same enthusiastic hopes that steel would supplant wood, but steel has found its place and concrete is merely another material that will also find its particular place.

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[1] Fruin-Colnon Contracting Co., St. Louis, Mo.

H. WADE HIBBARD spoke of his experiences in building a low-cost small wooden residence of slow-burning construction. After consultation with his architect, a slow-burning structure advocate, certain measures were determined upon with this end in view. The architect advised him, however, that it would be impossible to secure from any builder the faithful performance of such work that was out of the ordinary procedure in building construction. He was therefore obliged personally to oversee the work and even to perform some of it himself.

The steps taken to assure slow-burning construction included the setting of all wall and partition studding for the upper stories on a two-by-four laid on the floor below. The studding of each story had a two-by-four laid on top. In this manner a fire within the partitions and walls would be retarded at each floor by having to burn through 5 in. of wood. The flooring was in all cases made double, both rough and finished being matched, with either tin, sheet iron or usually slow-burning paper between, according to the danger above and below. All holes made through floors for plumbing or wiring were filled with brick and mortar. To delay a fire from passing out of the rooms into the partitions, all cavities for sliding doors were lined, and side plastering was carried down to the floor behind the baseboards. Of course such door cavities had sheet iron placed between rough and finished flooring. The next house he builds will have wire glass in the upper half of the windows. The chimney, lined with rectangular chimney tile, cemented end to end, was placed on the outside of the house and where it touched the wooden siding, six thicknesses of asbestos paper were inserted with joints broken. The same method was used around the fire place and its flue. The electric wiring, while kept inexpensive, was given special attention in the specifications, by the owner, architect and insurance inspector. Hot-water pipes for heating and for water service were wholly exposed. The heater was a steel boiler internally fired, without brick work, its top being some distance from the ceiling.

The kitchen, where there was a coal range, was partitioned off from the rest of the house by laying two thicknesses of almost incombustible seaweed building quilt in and out between the double zigzag line of studs. The double-rabbetted door between the kitchen and library was made of two thicknesses, with a layer of this quilting between. Quilting was used instead of sheet metal as a sound deadener.

Matches of the sort to be ignited on the box were placed out of convenient reach and permitted in the kitchen only. Oily rags and cloths for waxing floors and standing finish were kept in an incombustible receptacle. A fire extinguisher was placed convenient of access in the main hall; and in the basement, kitchen and bathroom ordinary garden hose were coiled ready to be attached instantly to hose faucets. The nearest house was over 100 ft. away and a slate roof seemed unnecessary, but exterior hose bibs were placed on both sides of the house.

As a result of these precautions against fire, this house was granted an insurance rate as low as that for a brick dwelling with a slate roof situated next to a fire company, instead of the maximum rate which is usually placed on suburban frame residences with poor fireproof protection.

Professor Hibbard advocated initial and occasional inspection by insurance companies carrying dwelling house risks, in order to lessen fire losses. Splendid results have thus been attained by the well-known factory mutual fire insurance companies.

The Author. Answering H. De B. Parsons, who states that the more fireproof a building is made, the greater will be its cost and the less its utility for modern demands, this is not always so, as is shown by the residence of Henry C. Mercer, Doylestown, Pa. (Figs. 28-31). Where Mr. Parsons cites unprotected columns failing from heat, he makes two very good illustrations of the difference between buildings of incombustible material and fireproof buildings. It is this distinction, so little understood by the average owner of buildings, that has caused the fire havoc in America.

Mr. Woolson's criticism of a centrally located concrete plant, that for efficiency and economy it would be necessary for such a plant to be in continuous operation, makes the point that I tried to illustrate the more obvious, namely, that such a plant would be in more nearly continuous operation than the plant of any small job. On a small job where labor is plentiful, it is more economical to put form builders to work until an entire story is ready to pour and then to lay them off than to use them at a higher rate of wages per hour than that of the concrete laborers. The reinforcement men may then be set to work, followed by the concrete laborers, and lastly by the cement finishers. Thus, for greatest economy on a small job, the mixing plant is in action intermittently, with all the inefficiency and wastefulness that accompanies any management that is continually disturbed, disrupted and changed.

On large jobs, the fact that a plant in continuous operation is most economical is so well realized that central mixing plants are the rule in many places, such as in the construction of the New York and Boston subways, where a central mixing plant was located in Post Office Square, a few blocks away from the nearest approach to the subway. The large mixing plants on the New York barge canal are good illustrations of central mixing plants.

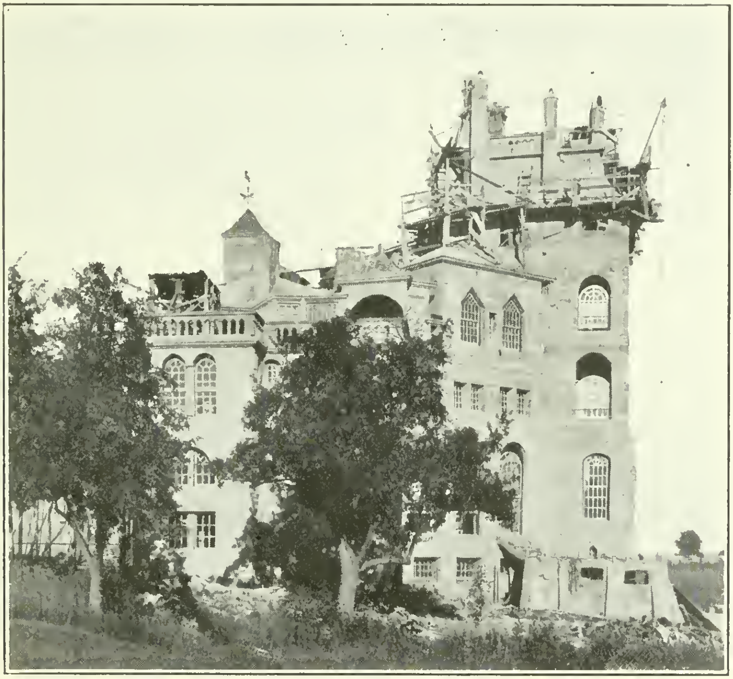

Fig. 28.—Residence of Henry C. Mercer, Doylestown, Pa., Built of Concrete

Such a plant has a great chance to operate continuously, because when work is interrupted at one location by a cave-in, change of operations, strike, lockout, change in plans, delay of reinforcement forms, weather or any other cause, the plant has just so much larger territory of working opportunity from which to draw. Furthermore, the total cost of mixing concrete by hand is often exceeded by that of machine mixing on small jobs by the burden of such fixed charges as hauling the mixing machine to the job, setting it up, operating, taking it down and removing, all of which is done but once on the centrally located plant. There is a large mixing plant at Manhasset Bay, Long Island, for mortar for supplying New York City.

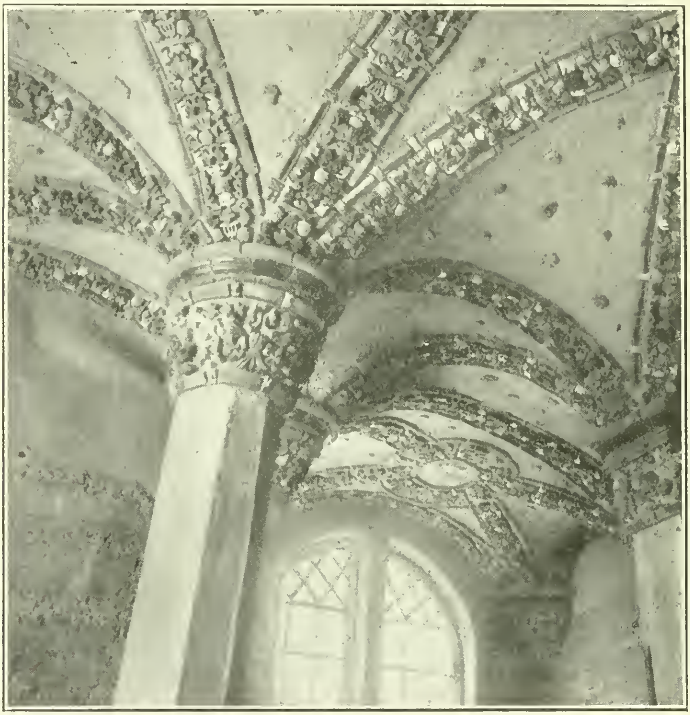

FIG. 29 RESIDENCE OF HENRY C. MERCER, SHOWING INTERIOR DECORATION

In reply to Mr. Woolson's statement that as a general proposition it is very difficult to make a handsome strictly fireproof dwelling and have it satisfy the artistic taste of the architect and owner, this was once quite true, but is no longer so. One need only visit the house of Henry C. Mercer to see that at last, an artist, maker of the famous Mercer clay art tile, has shown the way to make an artistic large or small concrete house, absolutely fireproof from every standpoint, at no greater expense than the cost of a wooden structure of the same size. No amount of fire from the furnishings of such a house could do more than a nominal damage that could be repaired at a nominal expense. There are no passages for fire, and almost no wood is used. The completion of the structural parts of the house was celebrated by a bonfire of the form lumber on top of the roof. This residence has done much as an object lesson of permanency, low cost, fireproof and artistic effect combined. Mr. Mercer has shown that this result can be obtained with inexperienced labor. He has also eliminated the necessity of fire insurance on or in a dwelling. His house answers Mr. Woolson's argument.

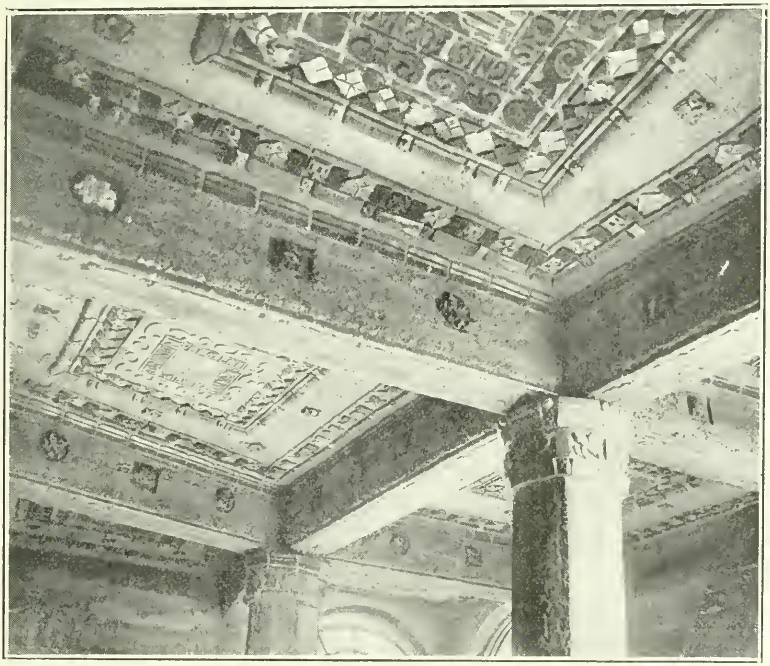

Fig. 30 Residence of Henry C. Mercer, Showing Ceiling Decoration

The statement made by Mr. Woolson that if the two or three conditions which are necessary to start a conflagration ever occur simultaneously, we will have a fire horror in this city which would discount the records of Boston, Chicago, Baltimore and San Francisco, is true. All who have studied the fire situation agree and know it to be true.

Mr. Woolson is the acknowledged authority on the relative combustibility of building material of the different kinds of construction. His experiments of burning many full-sized building units cover a long period of years, and the conclusions arrived at by him and by Mr. Macgregor of Columbia University are world standards today. *Remember his prophecy regarding the great fire that will some day destroy New York if we do not change our building methods.*

Replying to Col. Meier, there can be no question regarding concrete window frames being practical. One of many instances where concrete window sashes may be seen giving remarkable satisfaction, is shown in Fig. 32. They are permanent, fireproof, and even burglar-resisting. When their full benefits are appreciated the design of windows in our buildings will be changed. Col. Meier is undoubtedly correct when he states that the best construction would combine a concrete building with a sprinkler system.

Fig. 31 Residence of Henry C. Mercer, Details of Interior Decoration

Answering Col. Meier and Mr. Waterworth, the writer desires to call attention to the fact that their remarks as to difference in climate add force to the arguments in favor of the necessity of using less wood in American buildings. The dryness of our climate makes wood very susceptible to immediate ignition, but not so with brick, steel, or concrete. The habits and temperament of the people will not be a serious factor after wood in construction has been entirely eliminated.

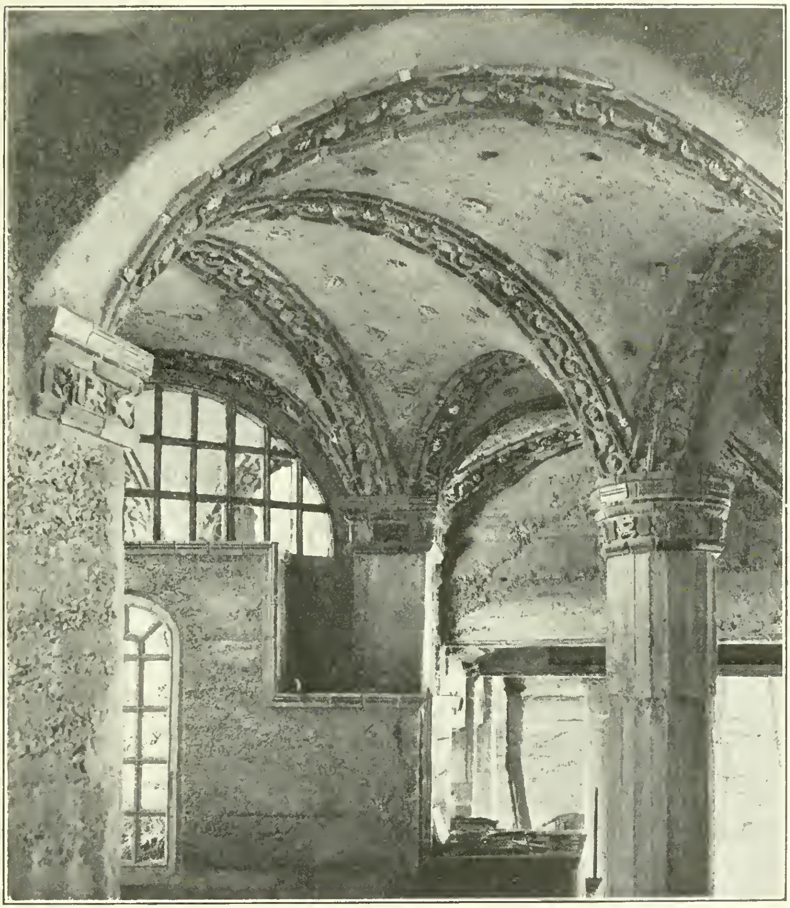

Fig. 32 Residence of Henry C. Mercer, Showing Concrete Window Sash

In answer to P. H. Bevier, who represents the combined manufacturers and dealers in hollow clay tile blocks, the writer desires to state that this paper was written after his having been personally in charge of laying hollow tile blocks of every description and also of concrete work since the year 1888. He has no reason, after reading Mr. Bevier's remarks, to revise any portion of his paper as printed.

For additional corroboratory evidence of the true condition of building materials, those interested should send for Bulletin No. 324, published by the United States Geological Survey, entitled The San Francisco Earthquake and Fire of April 18, 1906, and their Effects on Structures and Structural Materials. This book was written by the following well known experts: Richard L. Humphrey, Secretary of the National Advisory Board on Fuels and Structural Materials; John Stephen Sewell, Corps of Engineers, U. S. A.; Frank Soulé, Dean of the College of Civil Engineering of the University of California; G. K. Gilbert of the United States Geological Survey.

Examine Plate 25 *B* of this bulletin and see the concrete work on the Academy of Sciences Building. This building has been generally overlooked in the discussions regarding the resistance of good concrete to fire. It is an ideal example of complete concrete work remaining intact so that it would require no more than mortar and a plasterer's trowel to restore any of the concrete work. Had the entire city been of the same construction no unprejudiced person believes that the great catastrophe of the San Francisco fire would ever have occurred. This building is the work of Ernest L. Ransome, the father of concrete in America. It was the first commercial building with reinforced concrete floors in the western hemisphere and is a monument to Ransome that will ever be remembered by those who saw it and particularly by those who tried to take it down after the fire.

It must be remembered that Mr. Himmelwright's opinion, quoted by Mr. Bevier, regarding the Mutual Life Insurance Company's building, was based upon observation of the building after the fire, while the statements of the writer are based upon having seen it daily for weeks during the process of taking the building down piece by piece without succeeding in obtaining enough tile that would stay in one piece long enough to make one load to be sold as second-hand material. Mr. Bevier is quite correct in saying that the Mutual building was not a typical building from a hollow tile standpoint. It was not. It is one of the few buildings in which hollow floor and partition tile were used that did not suffer from failure of a large portion of the steel frame. In this building there was little or no failure of structural steel due to heat, except in the top story and other stories where the roof steel crashed through to the basement. Neither was there sufficient heat in the building to fuse any iron, nor to set the wooden flag pole on fire, nor even to scorch it or blister the paint on it.

Contrary to Mr. Bevier's remarks, it is possible to state with accuracy how much damage was done by the earthquake to the Mutual building, for the writer interviewed a man who went through the entire building after the earthquake and before the fire for the sole purpose of securing this exact information. Furthermore, Bulletin No. 324 of the United States Geological Survey states on p. 43: "The damage to this building (the Mutual Life Building, Sansome and California streets), from earthquake was very slight. The fire in the building, while not severe, was sufficient to cause the failure of the tile fireproofing of the roof trusses, which collapsed from exposure to heat."

The Mutual building is "unfair" as an example of the fire resisting properties of its fireproofing because it did not have any water thrown by the fire department upon the hot hollow tile. The safes did not cause the failure of some of the floor arches, as no safes were found in the basement; but would a safe in a burnt building be sufficient excuse for a "fireproof" floor falling? Is not the first requirement of a fireproof floor that it will hold up everything on top of it during and after a fire?

Undoubtedly there will always be some people who desire to put the various kinds of pipes behind the fireproofing that surrounds a structural column. Can any material that will not resist the action of being forced away by the bulging pipes be called as good fireproofing as is concrete? Those interested in the subject of fireproofing should read all of Mr. Himmelwright's valuable report.

The Mills, the Union Trust and the Flood buildings "were occupied within a few days after the fire," by a watchman perhaps, but they were not repaired for over a year after the fire. The failure of the terra cotta to remain in place in the Union Trust buildings can be seen in the United States Geological Survey, Bulletin No. 324, Plates 40, 45 and 50. These three buildings that Mr. Bevier cites as examples of buildings repaired at very little expense and occupied within a few days after the fire, are also fully discussed in this same bulletin. Quoting from p. 41:

> The hollow tile failed and left the steel skeleton exposed to the fire. . . . . Owing to the failure of the floor tile, many safes fell through the several floors. The building should be rebuilt.

On page 78 is a description of Aronson building:

> The ordinary ten-story steel-frame structure at the corner of Third and Mission Streets known as the Aronson Building had terra-cotta column coverings and partitions and cinder-concrete floors, all of which were of the types described in this paper as common in commercial buildings. The building seems

> to have been occupied for light commercial purposes, and the fire test to which it was subjected was therefore somewhat more severe than that prevailing in office buildings.
>
> A column in the basement was buckled, and two of the columns on the first floor were badly buckled near the ceiling as shown in Plate 27 *B*. These results, so far as the condition of the fire-proofing is concerned, are typical not only of the other stories of the Aronson Building, but of similar work in other buildings throughout the burned district. Some of the work in the Aronson Building was not severely tested by the fire and was still intact. An examination of it shows that it was as well done as similar work in any other commercial building in San Francisco. Where the fire was not very hot this kind of fireproofing protected the steel and suffered not more than 10 or 15 per cent of damage itself; where the fire reached the average temperature the fireproofing suffered a loss of 50 to 100 per cent, and where the fire was a little hotter than the average the total loss of the fireproofing and serious damage to the steel work was not at all uncommon. Damage to fireproofing such as that here described occurred in the James Flood Building, the Emporium Building, the building of the Spring Valley Water Company, the Mills Building, and every other building in which hollow tiles were used.

On p. 47 the condition of the Union Trust Building is described:

> The floors and partitions [of the Union Trust Company's ten-story building, Market and Montgomery Streets, were of hollow tile, and the girders, beams and columns were fireproofed with the same material. The floors were topped with cinder concrete covered with wood, except in the corridors, where cement finish was used. The cast-iron stairways had marble treads. The granite walls were spalled around the openings by fire. The hollow-tile partitions failed extensively and the lower web of the floor tile spalled over large areas. The fire was not intense, and the steel appeared to be in fair condition except on the ninth and tenth floors. . . . . The steel trusses on the tenth floor were very much distorted by heat, owing to the failure of the hollow-tile fireproofing.

On p. 147 is to be found the following statement:

> Good Portland-cement concrete has won a triumph for itself in fireproofing in San Francisco, for wherever well-made and properly laid upon the steel girders or columns, it protected the metal. In very hot fires the exterior portions were disintegrated and in some places the whole mass was cracked, necessitating removal, but the fireproofing it furnished during the conflagration was excellent. Examination showed also that it protected well against rust. The heat to which it was subjected was very great, in places common mortar being fused and ironwork walls melted. * * * * * * * * * * * * *
>
> As fireproofing for floors terra-cotta tiling has not given universal satisfaction. It is lighter than concrete, but the wrenching of buildings during the earthquake opened many of the joints and the mortar was destroyed—as in the Mills Building, a large ten-story steel-frame structure of the older type, hav-

ing self-supporting walls. The mortar joints in the tiling were started by the earthquake, and the mortar was disintegrated by the fire, the floors being destroyed and the lower surface of the tiling badly spalled. The same effect was noticeable to a certain extent in the excellent Union Trust, Crocker, and James Flood buildings. In the last named the flooring was fireproofed with terra-cotta arched tiles, covered with concrete on top and finished beneath by an efficient ceiling plastered on wire lath. The fireproofing was less injured in this building than in almost any other.

Terra-cotta fireproofing of columns was in many buildings a failure not so much on account of the nature of the material as because of its insufficiency in quantity and poor or imperfect method of application. Wooden studs were in many places put behind the terra-cotta. These burned out quickly, leaving the material unsupported. Pipes and wires were run up between the column and the fireproofing, and the twisting or expansion of the pipes caused by the earthquake movement broke the protecting cover. Imperfect junctions with ceilings above or floors beneath were common. That such imperfect construction should never be adopted has been fully demonstrated in San Francisco.

Plate 40 *B* shows the complete destruction of some fireproofing in the Mills building, together with the fact that its lack of fire protection resulted in one of the main columns of the building buckling and shortening several inches.

It is not the purpose of this paper to underrate the fact that hollow tile was a distinct step forward toward building with non-combustible material; but it has been stated that many buildings of hollow tile fireproofing in San Francisco were repaired at very little expense and were occupied within a few days after the fire, while two of the three buildings cited as the best examples, photographed and reproduced in the United States Geological Survey Bulletin, No. 324, record the fact, well known to those who were on the ground studying week after week the effects of the fire under different conditions on the different kinds of structural materials, that one could stand in the basement and see the sky. Although Mr. Bevier states that it was unfair to call the Mutual building of San Francisco a typical building, the same thing was true there. One could stand in the basement, look up through eight stories and see the sky with no obstruction except occasional bare iron beams.

The subject of this paper is fires, with the purpose of calling attention to the necessity, and practicability of eliminating wood in construction. Hollow tile is greatly preferable to wood, but Mr. Bevier makes some statements that are exactly opposite to the facts recorded by disinterested government experts.

Houses poured one story at a time are too numerous to cite. An architect named Morrill has poured many houses in metal molds in Washington, D. C., each distinctly different from the others. With the exception of Mr. Edison, all metal-mold advocates use interchangeable molds that can be set up to form any size, shape, kind or combination of building. Metal molds can be obtained without delay from Morrill of Washington, D. C., Diedritch of New York, the Concrete Standards Company of New York and the Blaw Company of Pittsburgh. Mr. Bevier should know that they are not new. The writer has used them over and over again, since as far back as 1896, and has found them economical and capable of producing a surface so smooth as to require no plastering.

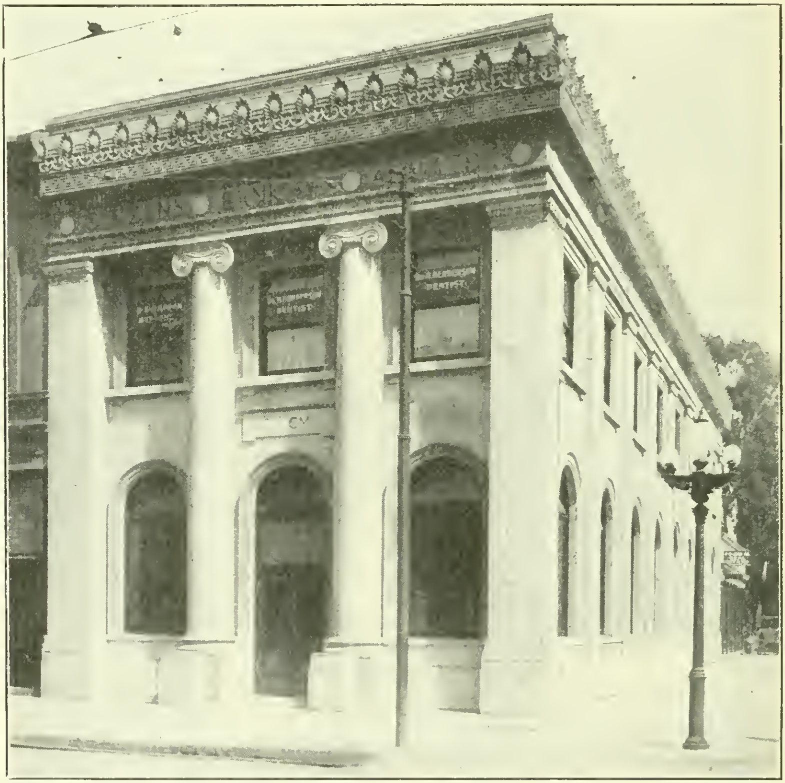

Fig. 33 Citizens Bank of Alameda, Cal., Where Soft Glue Molds were used for Ornamentation

Because of the use of metal molds there is no necessity to omit ornamentation. Metal molds can be used and a core box built in the wall for inserting especially molded and especially carved ornamental blocks of partially set concrete. Furthermore, special molds of soft glue can be used when deep undercut is desired. A photograph of the Citizens Bank of Alameda, where soft molds were most successfully used for such ornamentation, is shown in Fig. 33. Metal molds, such as those of the Concrete Standards Company, made in three sizes of dies, will make any kind or shape of building. When a piece of ornamentation is necessary it is made in accordance with any of the practices used for any other kind of molds. Therefore The Town Beautiful that Mr. Bevier fears for is in no way affected so far as interchangeable molds are concerned, except that costs are reduced to a point that will afford more money for further ornamentation.

Mr. Bevier says that flat ceilings are most desirable. When flat ceilings are desired they can be made easiest, strongest, quickest and cheapest with some such form of construction as the so-called mushroom system invented by C. A. P. Turner of Minneapolis, Minn. This system, while noted for its strength, is mushroom as to speed as well as to the shape of its columns. A flat ceiling as designed by Turner has no beams to interrupt light, interfere with the action of sprinkler systems, or to take up head room. It has all the advantages of a buckle plate in strength. It is of low cost because it requires the simplest of forms. When made of concrete it requires fewer coats of plastering. There are no corners or edges to be injured by fire. It can be reinforced in four directions, that is, north and south, east and west, northeast and southwest, northwest and southeast. When Mr. Bevier sells his blocks for a combination of hollow tile and reinforced ribs of concrete, the reinforcement in ribs runs one way only, for example, north and south.

If one desires to use hollow blocks with ribs of concrete, there can be obtained most excellent hollow tile made of concrete by some such process as the Pauly system. These tiles can be made at or reasonably near the site of the building. They do not, therefore, have to be shipped from a distantly located factory, with the expensive item for breakage. Being of the same material, they have the same coefficient of expansion by heat as the reinforced concrete ribs, and therefore crack less. Concrete tiles made by the Pauly process are accurate in shape and size, as there is no baking or consequent shrinking. They are so accurate in size that not only can they be laid cheaper than can any other tile, but they also require less plastering than tile made of any other kind of material. Furthermore, they have greater compressive strength per square inch than the clay tile that Mr. Bevier recommends.

Hollow blocks made of cement can be furnished for much less money than of baked clay. They are little chipped and broken, as they can be teamed from a local factory instead of being shaken and shunted by railroad delivery, consequently the loss from breakage is less. Furthermore, the mason is enabled to lay them much more accurately, and more quickly because of their greater accuracy.

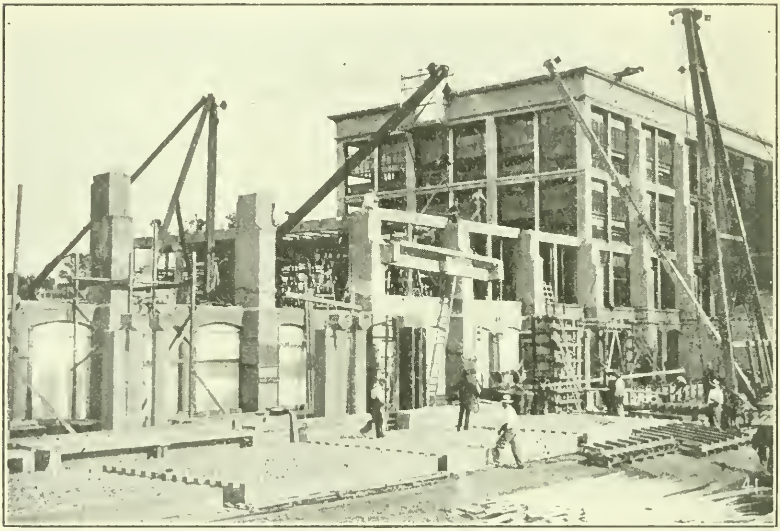

Fig. 34 United Shoe Machinery Company Concrete Building in Process of Construction

For places where hollow tiles are desirable, such as interior non-bearing partitions, those made of cement and the best quality of coarse sand or grit are more economical and more desirable from every standpoint. Hollow blocks made of cement and sand or grit are especially preferable where end construction is required. They are so nearly alike in size that less skilled workmen experience no difficulty in making the ends of the sides and partitions of the blocks rest accurately against the ends of the adjoining blocks, a comparatively difficult result to obtain in unevenly shrunk baked terra cotta, as any one knows who has actually laid it.

"That concrete walls can be poured in metal molds with sufficient accuracy to permit painting and wall papering without plastering or smoothing is another dream of the enthusiast which has not come to pass," to quote Mr. Bevier. It is only necessary to refer again to houses built by Morrill at Washington, D. C., and to call attention to the Times Square branch of the post-office on West 39th Street, New York, and to the office of Yale and Towne at Stamford, Conn. Many more illustrations of painting directly upon the concrete cast in wooden molds can be cited.

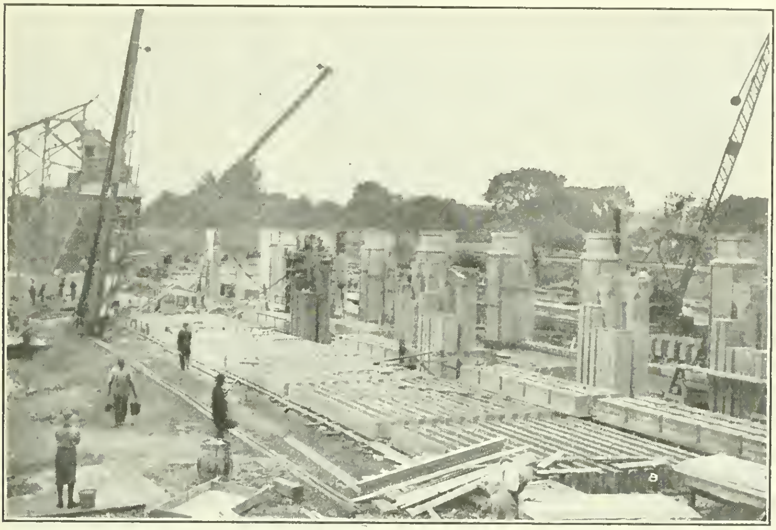

FIG. 35 CASTING SEPARATE MEMBERS FOR UNITED SHOE MACHINERY COMPANY BUILDING

In reply to Mr. Main, the writer has as additional evidence from a mill engineer in Mr. Main's office, Boston, a large cotton mill recently constructed for him of concrete at a price within 10 per cent of the cost of mill construction. The results in this particular case came first from designing the building in mill construction and then asking the concrete contractor to duplicate it in concrete. It would be interesting to know what the result would have been if the building had first been designed in concrete, particularly as to the most economical spacing of structural members for concrete, and then built in mill construction.

Taking Mr. Main's statement that in the textile mills the value of the building is not more than one quarter of the total value of the property, and his statement that concrete buildings cost even 25 per cent more, would it not be advisable to have legislation or a special tax on wood that by degrees would overcome this difference. There are also many by-products of loss to the country to offset the additional cost, if any, in the first cost of the buildings, such for example, as denuding our forests.

We must agree with Mr. Main that cotton and many other kinds of buildings should have complete sprinkler systems for the protection of their contents. His experience has been very great, many of the best textile and other mills in this country having been designed by him, but if he will visit the buildings now in process of erection for the United Shoe Machinery Company, at Beverly, Mass., he will see an indication of an entirely new type of concrete building construction that is coming.

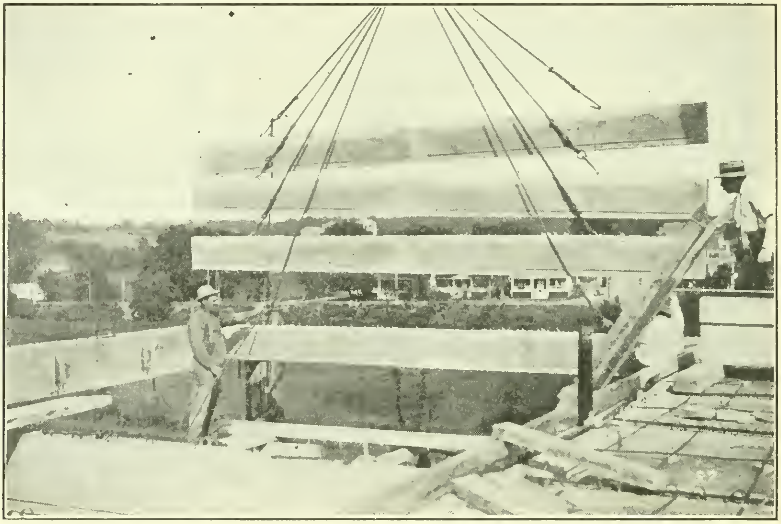

Fig. 36 Swinging Members into Position at United Shoe Machinery Company Building

This building, which can be built under factory conditions on either wet, cold or fair days, is shown in Fig. 34. Much of it can be cast while the cellar is being excavated. This type of construction is particularly adapted to the central mixing plant where the separately molded units can be cast, consolidated by power ramming and allowed to season and dry out long before being used (Fig. 35).

The speed with which a building of this type has been and can be built is limited only by the speed with which the pieces can be swung into place by a derrick (Fig. 36). The steel or wood or concrete windows can be set by the same derrick at a less expense than they can be set later in the old fashioned way. The fine steel windows of the Kahn Company and the Fenestra Company cost little, if any, more than wood by the time they are set, when handled by the same appliances that set the separately cast concrete sections. A building comparatively dried out at the time of completion is the result.

There are other advantages not so obvious. It is made in a manner that permits the output of a larger percentage of workmen to be measured separately than does any other type of building.

The author believes that many greater economies will be made in future in buildings of every kind by the application of Fred. W. Taylor's laws of scientific management because the units are made on the ground under factory conditions and the output of each individual therefore can be measured separately. The method of building by means of separately cast members, while primarily for the purpose of making quick, dry, economical and substantial construction, adapts itself particularly well to the operation of the principles of scientific management.

The era of concrete is here. It may never entirely supersede other forms of building construction, but it will always be used more or less with other forms of building materials. It must be supplemented by other materials that will assist to make the buildings fire resisting. As a building material, properly made concrete is the best fire resistant and retardant yet discovered. To this almost all unprejudiced experts in building design and construction now agree, and the time is not far distant when the verdict will be unanimous. In the meantime, everybody can encourage the disuse of wood in building construction and thus eliminate our great fire havoc.

THE ROTARY KILN

By Ellis Soper, Published in The Journal for October 1910

ABSTRACT OF PAPER

The paper gives a brief history of the development of the rotary kiln and commercially successful applications of it. A drawing is shown of a typical installation of an 8 ft. by 125 ft. kiln for burning cement by the dry process. The temperature curves are for a 7 ft. by 100 ft. kiln and there are three curves showing chemical changes in kilns of various sizes. There is also a table of kiln sizes, outputs and fuel consumptions with relation of the diameter to the length and the actual results from lengthening a 6 ft. by 60 ft. kiln. The heat balance, calculation of mixture, etc., is given for an 8 ft. by 125 ft. kiln operating upon lime rock and shale, using the dry process; also curves showing stresses in shell due to the improper spacing of tires, the fallacy of supporting upon more than two tires and the proper spacing of tires when the weakening effect of heat is considered. A fuel consumption curve illustrating the law of pivotal points, size of kiln conditions remaining constant, and output in barrels per day at which the fuel consumption is a minimum are stated.

ADDITION TO DISCUSSION[1]

E. S. Fickes. The history of the development and utilization of the rotary kiln is one of the most remarkable instances in modern engineering of neglecting to develop and use a valuable apparatus for years after its invention.

In the British patent granted to Chas. W. Siemens in 1869, Mr. Siemens states that he is well aware of the previous employment of revolving cylindrical calcining apparatus and he, therefore, makes no claim of novelty for the rotary kiln described in his patent. His patent is of great interest, however, on account of the broad grasp of the possibilities of the rotary kiln displayed by Mr. Siemens in drawing it. In his application Mr. Siemens mentions the use of his invention for the "calcination of metallic ores and also the burning of such substances as cement, lime or plaster of paris." His patent covers methods for utilizing the waste heat from the rotary kiln, the total calcination of metallic ores by bringing the heated ore into contact with heated atmospheric air alone, this being accomplished by advancing the point of combustion any desired distance into the rotating kiln, the introduction of jets of steam among the heated and partially reduced ores to produce further chemical reactions, the introduction of pulverized or liquid fuel into the kiln by means of a steam or air jet, the combination with the rotary kiln of a condensing chamber for the saving and utilization of sulphurous and other useful gases, the combining of such calcining apparatus with a smelting furnace so that the heat in the freshly calcined ore could be utilized in the smelting furnace, and the construction of the rotary kiln with a closed water-jacketed receiving chamber for the purpose of cooling pulverulent calcined materials without oxidation. It would be of interest to know something about the rotary calcining apparatus which was in use prior to 1869 when the Siemens' patent was granted, also to what extent the rotary kiln was developed and utilized under the Siemens' patents.

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[1] Discussion of The Rotary Kiln, Ellis Soper, published in The Journal for April 1911.

In 1885 patents were granted to Ransome for a combination of a rotary kiln and gas producer and some commercially unsuccessful attempts were made in England to use the apparatus to burn portland cement under this patent. As stated by Mr. Soper, a year later the real development of the rotary kiln for making cement began in this country. While producer gas was used successfully as fuel in one or two instances, it was soon found that it could not compete with powdered coal for burning cement clinker. For drying or calcining many materials, however, the use of powdered coal is very objectionable or even entirely out of the question on account of the ash from the coal mixing with the material under treatment and in such cases liquid or gaseous fuel must be used. Natural gas or oil is to be preferred, but their cost often necessitates the use of producer gas.

While the rotary kiln within the last ten years has come into general use in the cement industry, its use for drying, roasting and calcining other materials is by no means so great as is warranted by its utility and the economies which can be effected by its use. Although the Siemens' patent mentions the burning of lime, and Henry Mathey was granted United States patents in 1885 for a process for making lime by crushing the stone to a suitable fineness and then burning it in a rotary kiln, the writer does not know of lime being successfully burned on a commercial scale in a rotary kiln in the United States until 1893 when it was so made by the California Portland Cement Company.

In 1905 or 1906 the New York Lime Company started to burn lime at Natural Bridge, N. Y., using a 100 ft. by 6 ft. rotary kiln fired by gas from a 10-ft. Morgan producer, and in 1907 both the Union Carbide Company and the Aluminum Ore Company built rotary kiln lime plants, the latter using 120-ft. kilns and having a capacity of from 200 to 300 tons of lime per day.

In 1902 the writer installed a 60 ft. by 5 ft. rotary kiln for drying and dehydrating bauxite, using producer gas as fuel. Since then he has built additional drying plants of this type and several similar plants for chemical industries, one of which consists of four 120 ft. by 7 ft. rotary kilns employing a temperature of 2000 deg. fahr. for dehydrating salts containing chemically combined water. The fuel used is producer gas and an elaborate separating and gas washing apparatus was installed in connection with this plant to save the valuable dust carried off by the waste gases from the kilns. In none of these plants could powdered coal be used on account of the ash resulting from its combustion.

The writer quite agrees with Mr. Soper regarding the use of the rotary kiln as a direct heat dryer and has used it in preference to patent dryers whenever the output and character of the material to be dried would warrant its use. Used as a dryer, the simple and strong construction of a good rotary kiln insures a large output with low maintenance cost and few interruptions, which is far from being true of many other kinds of dryers. The limited use of the rotary kiln as a dryer is only less remarkable than the slow progress it has made in chemical and metallurgical plants where it can often be used in place of much more expensive and less efficient apparatus.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(VI)

ARTICLES IN PERIODICALS

Aero and Motor Boat Show, The. *The Engineer (London), March 31, 1911.* 2½ pp., 7 figs. *Cabcf.*

A comment upon the motor boat, hydroplane and aeroplane engines exhibited at Olympia, emphasizing various qualifications and suggested requirements.

Aeroplane Motor, The Woseley Eight-Cylinder. *London Engineering, March 24, 1911.* 1½ pp., 3 figs. *bc.*

Details of construction of 60-h.p. and 120-h.p. motors.

Calorimeter, The Doherty Gas. *The Iron Age, April 13, 1911.* 1½ pp. 2 figs. *bc.*

A description of a calorimeter in which the calorific value of any combustible gas can be measured with little or no calculation on the part of the operator.

Coal, An Engine that Generates its Own Gas from. *Power, March 14, 1911.* 1 p., 3 figs.

A gas generator and engine combined for which the inventor claims a fuel consumption of 0.4 lb. coal per b.h.p-hr.

Compression. *Gas Power, March 1911.* 1 p.

How to determine the necessary amount and how it often affects the engine.

Crosshead Stop, Does the, William T. Kingsley. *Power, February 7, 1911.* ½ p., 1 curve.

Proved that it does not.

Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A, B, C.* The first installment was given in The Journal for May 1910.

ENGINE IN THE AGRICULTURAL FIELD AT HOME AND ABROAD, THE GASOLINE, George Cormac, Jr. *Gas Power, March 1911.* 5 pp.

Economy.

ENGINES FOR NAVY LAUNCHES, INTERNAL-COMBUSTION, Lieut. W. G. Diman. *American Society of Naval Engineers, August 1910.*

Report of trials at Norfolk navy yard of 2 and 4-cycle gasolene engines. Also giving Lloyds rules for internal-combustion engines.

ENGINES FOR SUBMARINES, OIL. *The Engineer (London) March, 24, 1911.* 2½ pp., 7 figs. *bf.*

Descriptive of the Koerting Bros. single-acting, 2-cycle type, valveless oil motors, built for the Norwegian submarine Kobben.

ENGINES, LARGE TWO-CYCLE. *The Engineer (London), March 3, 1911.* 1 p., 4 figs. *Cabf.*

Extract of paper by A. E. L. Chorlton before the Manchester Association of Engineers.

ENGINES OF THE TWO-CYCLE TYPE, LARGE GAS, A. E. L. Chorlton. *London Engineering, March 10, 1911.* 8⅓ pp., 16 figs., 2 tables. *bdf.*

Also *March 24, 1911.* 7 pp., 7 figs, 2 tables, 7 curves. *bc.*

Paper before Manchester Association of Engineers, February 25, 1911.

FIRE SERVICE WATER WORKS SYSTEM OF WINNIPEG, Lieut. Col. N. H. Ruttan. *Proceedings American Water Works Association, 1911.* 15 pp., 7 figs., 1 map.

General description of plant and test of station using producer gas, emergency, connection to city gas mains.

GASHEIZUNG FÜR KIRCHEN, DIE BEDEUTUNG, P. Spaleck. *Journal für Gasbeleuchtung und Wasserversorgung, February 11, 1911.* 4 pp. ,2 figs.

Also *February 25, 1911.* 2½ pp., 5 figs., 1 curve. *B.*

The importance of gas heating for churches and large halls.

GENERATOR MIT GEWINNUNG DES DAMPFER DURCH VERBRENNUNG DES GENERATOR GASES OHNE DAMPF RESSEL SYSTEM-STRACHE, A. Breising. *Dinglers Polytechnisches Journal, March 4, 1911.* 1½ pp., 1 fig., 1 table. *Abf.*

Water gas generator in which the necessary steam is developed in a pipe system heated by the gases from the generator omitting a separate steam boiler.

IGNITION, GAS ENGINE, E. Q. Williams. *Gas Power, February 1911.* 2 pp.

IGNITION ON THE EFFICIENCY AND OUTPUT OF INTERNAL COMBUSTION ENGINES. THE INFLUENCE OF MULTIPOINT, Otto Heines. *The Gas Engine, April 1911.* 4 pp. 1 fig., 1 table, 8 curves.

Paper before the Society of Automobile Engineers. Shows the loss in efficiency due to the ignition lead required to compensate for the time of flame propagation and how this may be remedied by two ignition points. Tests with single and two point ignition with curves showing effect on horsepower developed, reduction of lead, and the power developed at various degrees of advance.

HEAT TO TURBINE, GAS ENGINE WASTE, E. D. Dreyfus. *Power, April 11, 1911.* 7¼ pp., 2 figs., 10 curves. *bc.*

A description of a composite steam and gas plant using waste heat from gas engines to generate steam for low-pressure turbines.

INDICATOR, REDUCING MOTION FOR GAS ENGINE, R. G. Brown. *Power, February 7, 1911.* 1 p., 2 figs., 1 curve.

METER, THE THOMAS. *The Iron Age, March 16, 1911.* 3 pp., 6 figs., 1 curve. *bf.* Electrically operated device for measuring gases of all kinds.

MOTOR BOATS, TWO. *The Engineer (London), March 31, 1911.* 1½ pp., 5 figs. *Abf.*

Describes fireboat Gamma of the London Fire Brigade and the motor driven oil barge Rocklight of the British Petroleum Company. The fireboat Gamma is 66 ft. 6 in. long by 11 ft. 6 in. beam, driven by two Thornycroft *D*4 paraffin motors which develop 80 h.p. at 700 r.p.m. These motors are also used for driving the high-pressure pumps. The oil barge Rocklight is 100 ft. 6 in. long by 17 ft. beam. Motion power consists of a six-cylinder Thornycroft motor developing 70 h.p. at 750 r.p.m.

MOTORS, MARINE DIESEL. *International Marine Engineering, April 1911.* ½ pp.

Describes paper before German Naval Architects by Director Samberlich of Osterholz-Scharmbeck, Bremen.

PRODUCCION DE GAS HIDROCARBURO AL VACIO. *El Comercio, January 1911.* ½ p. *ab.*

A new system of carburetting in vacua.

PRODUCER, ELEMENTARY LECTURES ON THE GAS, C. P. Poole. *Power, March 14, 1911.* 3⅓ pp., 3 figs. 3 tables. *bc.*

Usefulness of the economizer, effect of the vaporizer, vaporizing in the ash pit. Calculations for the saving effected by preheating the air by the outgoing gases.

PRODUCER-GAS ENGINE PLANTS, GAS, W. O. Webber. *The Iron Age, March 16 1911.* 2⅓ pp., 3 tables, 5 curves. *abf.*

Details of installation and maintenance cost.

Producer Plant, A Composite Pressure and Suction. *Power, April 4, 1911.* $1\frac{1}{3}$ pp., 5 figs. *b.*

Describes a New England manufacturing plant equipped with three generators and two combination type scrubbers. An unusual feature of this plant is the use of both suction and pressure to create draft through the generator

Pumping Stations on the Manchester Ship Canal. *The Engineer, March 24, 1911.* $\frac{1}{2}$ p., 3 figs., 1 table. *bf.*

Describes oil pumping station of 22,000 gal. per min. Driven by 200 h.p. Mirrless-Diesel engine, coupled to a 36-in. Drysdale centrifugal pump.

Ratios Gas Engine Compression and Expansion, C. P. Poole. *Power, March 21, 1911.* 2 pp., 2 figs., 3 tables. *e.*

Starting and Reversing of Marine Gas Engines, Reliable, E. N. Percy. *Gas Review, February 1911.*

Torfmoore unter Berücksichtigung der Krafterzeugung, der Gewinnung der Nebenerzeugnisse und der Beeinflussung unserers Volkswohlstandes. *Zeitschrift des Vercins deutscher Ingenicure, March 11, 1911.* 5 pp., 1 fig. *bdef.*

On the utilization of turf with regard to power production, the recovery of the by-product and its influence for public good.

Turbines, Gas. *The Gas Engine, April 1911.* 4 pp., 1 table, *Aacd.*

Extract of paper by H. Grinsted, before Coventry Branch of Institute of Automobile Engineers. Discusses the thermo-dynamic side of the question and points out the desirable qualities which may be obtained when the gas turbine has been perfected. Reviews the practical work done in the gas turbine field and compares the results with gas engines.

Verbrennungsmaschinen, Die Wohl des Zundzeitfunktes bei Fahrzeug, A. Heller. *Zeitschrift des Vereins deutscher Ingenieure, February 25, 1911.* 2 p., 3 figs., 4 curves.

An article on ignition.

GENERAL NOTES

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The President and Board of Directors of the American Institute of Electrical Engineers extend a cordial invitation to the members and ladies of The American Society of Mechanical Engineers to be present at their Annual Meeting, held on Tuesday evening, May 16, 1911, in the Auditorium of the Engineering Societies Building, at which there will be the formal presentation of the Edison Medal to Frank J. Sprague. There will also be four addresses by prominent speakers on appropriate topics.

THE CIVIC FORUM

An address on The New Conception of Business and Industrial Efficiency was given by Frederick W. Taylor, Past-President Am.Soc.M.E., in Carnegie Hall, New York, April 28, before The Civic Forum, an educational society for the discussion of public questions. Brief addresses were also made by John Golden on the Attitude of Organized Labor towards Scientific Management and by Frank B. Gilbreth, Mem.Am.Soc.M.E., on the Practical Application of Scientific Management.

AMERICAN INSTITUTE OF MINING ENGINEERS

A meeting of the American Institute of Mining Engineers will be held June 6-10, 1911, in the Pennsylvania anthracite region, where the institute was organized at the Wilkes-Barre meeting of May 1871. Headquarters will be at the Glen Summit Springs Hotel, Glen Summit Springs, Pa. Visits are planned to the Hazard Wire Rope Works and to the new concrete and iron breaker of the Lehigh Valley Coal Company; to Lehigh University to inspect the John Fritz Engineering Laboratory and the E. B. Coxe Mining Laboratory; to the Bethlehem Steel Works; the anthracite coal-storage plants of the Lehigh Valley Coal Company, and the briquetting-plant of the Lehigh Coal and Navigation Company; the Summit Hill mine-fire, returning by way of the switchback to Mauch Chunk, and thence to Glen Summit; and to the underground workings of various coal mines. Among the papers announced for presentation are the following: A Drafting Table for Tracing through Opaque Paper, A. T. Schwennesen; Proposed Code of Rules for Installation and Use of Electricity in Mines, S.A. Taylor; The Application of the Equation of the Straight Line to the Reduction of Triangulation Readings, L. D. Moore; The Fuel-Efficiency of the Iron Blast Furnace, J. J. Porter; Some Radical Improvements in the Practice of Concentrating Minerals by the Use of Wet Tables, S. A. Krom; Electrical Practice in

Mines, B. McCollum; The Bituminous Coal Industry, S. K. Smith; History and Geology of Ancient Gold-Fields in Turkey, L. Dominian; Tunnel Driving in the Alps, W. L. Saunders; The Storage of Anthracite Coal, R. V. Norris, Mem. Am. Soc.M.E.; The Anthracite Arbitration Board, S. D. Warriner, Mem.Am.Soc. M.E.; Briquetting-Plant of the Lehigh Coal and Navigation Company, C. Dorrance, Jr.

AMERICAN ACADEMY OF POLITICAL AND SOCIAL SCIENCE

The annual meeting of the American Academy of Political and Social Science was held April 7 and 8, 1911, at Witherspoon Hall, Philadelphia, Pa. The five sessions of this meeting were devoted to the discussions of such questions as Industrial Accidents and Their Prevention, Employers' Liability and Workmen's Compensation. The meeting took the form of a great national conference to consider and discuss the experience of the different sections of the country and to reach some conclusion as to the measures which should be adopted in order to harmonize the industrial interests of the country with the legitimate demands of the laboring classes. The Society was represented by James Christie, J. Sellers Bancroft, John N. Birkinbine, Geo. W. Melville and Arthur C. Jackson. James M. Dodge, Past-President of the Society, was a member of the committee to arrange a special exhibit of safety devices. A paper on Work of the United States Government in the Prevention of Accidents was read by J. A. Holmes, Mem. Am. Soc. M. E., as were many others dealing with the various phases of the subject.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

The annual meeting of the National Association of Cotton Manufacturers was held at the Massachusetts Institute of Technology, Boston, April 12 and 13, 1911. One of the first items of business was the presentation of the association medal to Chas. T. Main, Mem.Am.Soc.M.E., in recognition of the merits of his paper on Choice of Power for Textile Mills and his contributions to mill engineering. President Maclaurin of the Massachusetts Institute of Technology delivered an address and papers were read on the following subjects: Arbitration on Cancellation of Orders, Coöperation between Bureaus of the Federal Government and Textile Manufacturers; Efficient Buying of Raw Material; How the Cotton Industry has Safeguarded its Employees; Law of Moisture in Cotton; Power from Producer Gas, Production of Cotton in the Honolulu Islands, Renaissance of the Waterfall, Risks of Cotton Manufacturing, Standardizing the Artificial Illumination of Cotton Mills, Textile Education from a Manufacturing Standpoint, Transmission of Power by Ropes and Uniform Contracts. Col. E. D. Meier represented the Society at the meeting and spoke briefly of the relation between the mechanical engineer and the cotton industry. One of the special features of this convention was the demonstration on the Massachusetts Institute of Technology lawn of a cotton-picking machine.

WATER POWER CONSERVATION CONGRESS

A public conference on waterpower conservation was called on April 8, 1911, in the Engineering Societies Building by the transmission section of the National Electric Light Association. In order to give the best opportunity for a general interchange of ideas the conference was divided into two sessions, the papers being presented in the afternoon, when the general status of present conservation policies were reviewed, and the entire evening session being devoted to a discussion of conservation problems. The attendance was large and a number of men closely identified with water power development throughout the United States took part in the open discussions. Secretary of the Interior Fisher made a brief address in which he stated that the government had no set legislative policy concerning conservation, but that the aim had been, rather to maintain the present status until a suitable policy could be decided upon. It was his opinion that the State and the Federal government has no conflicting interests in such legislations. Papers were read by S. Z. Mitchell, J. R. McKee, Richard Lamb, H. E. Cutter, J. G. White and Mr. Frothingham. Discussion by C. F. Scott, R. D. Mershon, Mem. Am .Soc. M. E., F. J. Sprague, P. H. Thomas, D. B. Rushmore, Mem.Am.Soc.M.E., and John Bogart brought out interesting phases of the conservation question.

BROOKLYN ENGINEERS' CLUB

An exhibit of engineering materials, models and plans of engineering machinery, together with photographs and drawings of important engineering structures was held at the club-house, 117 Remsen Street, April 17–22, 1911. The exhibit included a variety of subjects from a model of a refuse destructor plant to one showing the complete working of a modern fire alarm system. Descriptive and explanatory talks were given in which the workings and uses of some of the various exhibits were explained. The engineers of the Public Service Commission showed the plans of the new Fourth Avenue Subway, now under construction in Brooklyn, together with charts made and the methods employed.

TECHNOLOGY CONGRESS AT BOSTON

The fiftieth anniversary of the founding of the Massachusetts Institute of Technology was commemorated at Boston on April 10 and 11, 1911, by a Congress of Technology, which was attended by a large number of scientists and engineers from all parts of the country and at whose sessions about 60 papers were presented covering a wide range of industrial, financial, economic and engineering topics. Through a broad treatment of topics the various papers did much to summarize the latest progress in the fields of sanitation, railway administration, efficiency management, industrial education, conservation, metallography, research, chemistry, architecture, mechanical and electrical engineering; but beyond this the needs of the future were frequently indicated in specialized departments, and the direct connection between science and commercial progress was repeatedly emphasized. There were four paper contributed by members of the Society, namely, The Continuous Cooling of Circulating Water Used in Condensing Steam, E. F. Miller; Scientific Industrial Operation, Tracy Lyon; Thirty Years' Work in Boiler Testing, G. H. Barrus; The Prevention and Control of Fires through Scientific Methods, E. V. French. The Society was officially represented at the Congress by its President, Col. E. D. Meier.

NATIONAL METAL TRADES ASSOCIATION

The annual convention of the National Metal Trades Association was held at the Hotel Astor, New York, April 12 and 13, 1911. William Butterworth chairman of the Committee on Employers' Liability Insurance, reported on that subject and R. C. Bolling, M. M. Dawson, J. A. Macdonnell and H. V. Mercer discussed it.

ECONOMIC CLUB

At the annual dinner of the Economic Club at the Hotel Astor, New York, the subject of scientific management of industrial plants was discussed. James O. Fagan and James Duncan represented the labor point of view. They expressed deep distrust of the new ideas, and said that to the employee the principle of settling his work on a scientific basis means ultimately the exaction of a greater amount of work by the employed for the same rate of pay as at present. Harrington Emerson, Mem. Am. Soc. M. E., L. D. Brandeis, H. R. Towne and Frank B. Gilbreth, Mem. Am. Soc. M. E., were the set speakers for efficiency management and testified that they have adopted it in their own works and found it to work not only to their advantage, but to the advantage of the employees as well.

PERSONALS

L. B. Alexander, formerly assistant chief of department of the Bosch Magneto Co., New York, has been appointed general sales manager of the same company.

W. H. Baltzell, recently chief engineer of the Donora Steel Works, Donora, Pa., has accepted a similar position with the Pittsburg Crucible Steel Co., Pittsburg, Pa.

John H. Barker has been appointed manager of the New York office of the Diehl Manufacturing Co. He was formerly salesman of the special apparatus department of the same company.

George G. Bennett, formerly connected with the engineering department of the American Thread Co., Holyoke, Mass., has become efficiency engineer for the Ludlow Manufacturing Associates, Ludlow, Mass.

William P. Bixby has accepted a position with the Union Wadding Co., Pawtucket, R. I. He was until recently identified with the mechanical department of the Erie Railroad Co., New York.

Jos. K. Blum has accepted a position with the Coplay Cement Manufacturing Co., New York, as mechanical engineer.

Walter E. Brown, formerly assistant engineer and superintendent of the Penn Motor Car Co., Pittsburg, Pa., has become affiliated with the Middleby Auto Co., Reading, Pa., in the capacity of superintendent.

Wm. Clinton Brown, consulting engineer, formerly located at Montreal, Canada, has been appointed chief engineer of the Humphrey Gas Pump Co., Syracuse, N. Y.

A. O. Carpenter has become associated with the designing department of Ingersoll-Rand Co., Painted Post, N. Y. Mr. Carpenter was formerly identified with the Chicago Pneumatic Tool Co., as chief draftsman of their Franklin, Pa. plant.

Robert L. Cork, formerly associated with the Western Gas Construction Co., Fort Wayne, Ind., has been appointed chief engineer of the Almont Manufacturing Co., Almont, Mich.

M. Craighead has become connected with the sales department of the Link-Belt Co., representing them in Boston. He was formerly associated with the Lehigh Coal & Navigation Co., Philadelphia, Pa.

Fred H. Daniels, chief engineer of the American Steel & Wire Co. has been made chairman of the Shop Committee of the Board of Trustees of the Worcester Polytechnic Institute, Worcester, Mass.

John Fallon has resigned the position of assistant engineer with the Tennessee Copper Co., Copperhill, Tenn., to become associated with Percival Robert Moses, consulting engineer, New York.

Hardy S. Ferguson, formerly chief engineer of the Great Northern Paper Co., Millinocket, Me., has opened an office in New York, as a consulting engineer.

Geo. F. Gast has become connected with the construction department of the Minnesota & Ontario Power Co., International Falls, Minn. Mr. Gast was until recently chief draftsman and construction engineer with Walter Kidde, New York.

Waldo G. Gernandt has accepted a position with the Packard Motor Car Co., Detroit, Mich., as designer in the carriage chassis department. He was formerly factory engineer of the Rapid Motor Vehicle Co., Pontiac, Mich.

E. L. Hill, recently appointed assistant superintendent of the American Steel and Wire Co.'s electrical cable works in Worcester, Mass., has been made superintendent of the plant.

Reuben Hill, formerly identified with the Hudson Motor Car Co., Detroit, Mich., has assumed the duties of superintendent of the Detroit Lubricator Co., Detroit, Mich.

A. L. Kenyon has been appointed chief of construction for the Georgia Power Co. at Tallulah Falls, Ga. He was formerly identified with the Empesas Electricas Associadas at Lima, Peru, in the capacity of chief engineer.

A. G. Kessler has become connected with the Ball Engine Co., Erie, Pa. He was recently associated with the engineering department of R. G. Peter's Manufacturing Co., Grand Rapids, Mich.

W. S. Lee, chief engineer of the Southern Power Co., Rock Hill, S. C., has been elected vice-president and chief engineer of the Greenville, Spartanburg & Anderson Railway, Greenville, S. C.

L. B. Lent has severed his connections with the Riverside Engine Co., New York, to assume the duties of chief engineer of the New York Blaugas Co., with headquarters at Brewster, N. Y.

John P. McJilton, formerly associated with the American Locomotive Co., Schenectady, N. Y., as draftsman of the superheater department, has assumed the position of draftsman for the Locomotive Superheater Co., New York.

J. H. Maysilles has resigned the position of general foreman of the electric locomotive and truck department of the American Locomotive Co., Schenectady, N. Y., and has accepted the position of superintendent of the Davenport Locomotive Works, Davenport, Ia.

C. J. Morrison has become identified with the department of effective organization of Suffern & Son, New York. This department, under the direction of Mr. Morrison, has been organized to aid in securing the most effective organizations and the most efficient methods in manufacture and business.

J. N. Mowery, formerly connected with the L. V. R. R., Auburn, N. Y., as master mechanic, has accepted a similar position with the N. Y. N. H. & H. R. R., Waterbury, Conn.

Stephen Quinn, formerly chief engineer of the Iola Portland Cement Co., Iola, Kan., has accepted a similar position with the Knickerbocker Portland Cement Co., Hudson, N. Y.

Charles R. Richards, dean of the college of engineering of the University of Nebraska has been appointed professor of mechanical engineering, in charge of the department at the University of Illinois. The appointment takes effect September 1, 1911.

John D. Riggs, has accepted a position as chief draftsman with the Oliver Chilled Plow Works, South Bend, Ind. He was formerly connected with the P. M. & Co., Chicago, Ill., as tool designer.

John W. Sheperdson formerly steam engineer of the Cambria Steel Co., Johnstown, Pa., has been promoted to assistant superintendent of the gautier department of the same company.

Henry D. Watson, for a number of years assistant manager of the Westinghouse Machine Co., New York, has resigned his position to become the Eastern sales manager of the Saurer Motor Co. with offices in New York.

H. J. White has resigned the position of mechanical expert with the Lanson Monotype Machine Co., of Philadelphia, Pa., to assume the duties of works manager and mechanical engineer of the Krantz Manufacturing Co., Brooklyn, N. Y.

William L. Wilson has left the employ of the Aluminum Co. of America, Chicago, Ill., as salesman, to accept the position of vice-president of The Electric Installation Co., Baltimore, Md.

Oliver B. Zimmerman has accepted a position with E. Burner & Co., South Bend, Ind. He was formerly identified with M. Rumely Co., La Porte, Ind.

ACCESSIONS TO THE LIBRARY

This list includes only accessions to the library of this Society, included in the Engineering Library. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am. Soc. M. E.

L'Aerophile. Years 1–7; 8, nos. 7, 9, 11; 9, nos. 1–4, 6, 8–12; 10, nos. 1–11; 11; 12, nos. 2–3, 5–12; 13; 14, nos. 1–6, 9, 11, 12; 15, nos. 2–4, 6–8. *Paris, 1893–1907.*

American Civil Engineers' Pocket Book. By Mansfield Merriman. *New York, J. Wiley & Sons, 1911.*

American Producer Gas Practice and Industrial Gas Engineering. By Nisbet Latta. *New York, Van Nostrand, 1910.*

American Railway Bridge and Building Association. Proceedings of 20th annual convention, 1910. *Chicago, 1910.* Gift of the association.

American Water Works Association. Proceedings of 9th and 10th annual meetings, 1889–1890. *1889–1890.* Gift of the association.

Applied Mechanics. By John Perry. *New York, Van Nostrand, 1907.*

Association of American Portland Cement Manufacturers. Bulletin, nos. 12, 18. Gift of the association.

Beton und Eisen. Years 3–5. 1904–1906. *Berlin, 1904–1906.*

Bibliography of the Cotton Manufacture. By C. J. H. Woodbury, vol. 2. *Waltham, 1910.* Gift of the author.

Boiler Explosion at Morewood Lake, Pittsfield Mass. *Boston, 1911.* Gift of the Commonwealth of Massachusetts.

Cane Sugar and Its Manufacture. By H. C. P. Geerligs. *Altrincham, 1909.*

Chicago City Council. Journal of the Proceedings of the City Council. December 1, 1910. Gift of the Chicago Bureau of Statistics and Municipal Library.

Chicago Department of Smoke Inspection. Report. February 1911. *Chicago, 1911.* Gift of the department.

Concrete Review. Vol. 4, nos. 1–2, 5–7, 10. Gift of the Association of American Portland Cement Manufacturers.

Connecticut Bureau of Labor Statistics. 24th Report. *Hartford, 1910.* Gift of the bureau.

Drying Machinery and Practice. By T. G. Marlow. *New York, Van Nostrand Co., 1910.*

Electric Wiring, Fittings, Switches, and Lamps. By W. P. Maycock. ed. 4. *London, New York, 1911.*

Elements of Descriptive Geometry. By A. E. Church and G. M. Bartlett. *New York, American Book Co., 1911.*

Fuller-Lehigh Pulverizer Mill. Gift of the Lehigh Car, Wheel and Axle Works.

Le Genie Civil. Vols. 1–23, 1880–1893. *Paris, 1880–1893.*

HARDWOOD FINISHER. By C. Godfrey. *New York, Industrial Publication Co., 1908.*

HARVARD UNIVERSITY. Report of the President and Tresurer 1909–1910. *Cambridge, 1911.* Gift of the university.

HYDRAULIC PROPERTIES OF REGROUND CEMENT MORTARS. By H. S. Spackman and R. W. Lesley. Gift of the Lehigh Car, Wheel and Axle Works.

HYGIENE IN HEATING. By Konrad Meier. Reprinted from Heating and Ventilating Magazine, January 1911. Gift of the author.

ICE AND REFRIGERATION BLUE BOOK. 1909. *Chicago, New York, Nickerson & Collins Co.*

IGNITION HAND BOOK. By H. R. Van Deventer. *1911.* Gift of Sumter Telephone Mfg. Co.

INDUSTRIAL PLANTS, THEIR ARRANGEMENTS AND CONSTRUCTION. By Chas. Day. *New York Engineering Magazine. 1911.*

LOUISIANA PLANTER, THE. Vol. 38, nos. 2, 23, 26; Vol. 39, nos. 1 10; Vol. 40, no. 14; Vol. 41, no. 24; Vol. 42, no. 5. *New Orleans, 1907–1909.* Gift of the Louisiana Planter.

LOGARITHMIC TRIGONOMETRICAL TABLES, WITH EIGHT DECIMAL PLACES. By J. Bauschinger and J. Peters. Vol. 1. *Leipzig, 1910.*

NATIONAL COMMERCIAL GAS ASSOCIATION. Proceedings of the 6th annual meeting, 1910. *1910.* Gift of the association.

NEW JERSEY BOARD OF PUBLIC UTILITY COMMISSIONERS. 1st Annual Report. 1910. *Trenton, 1911.* Gift of the board.

NEW YORK CITY BOARD OF WATER SUPPLY. 4th Annual Report. 1909. *New York, 1909.* Gift of the board.

NEW YORK CITY BOARD OF WATER SUPPLY. Annual Report. 1906. *New York, 1906.* Gift of the board.

——Specifications and contracts. Nos. 3–4, 9–10, 12, 15, 20, 24, 30–31, 39, 42–44, 47–48, 53–55, 59, 60, 68, 73. *1907–1910.*

——Contract drawings to Nos. 3–4, 9, 10, 12, 15, 20, 24, 30–31, 42–44, 47, 53–55, 59, 60, 68. Gift of the board.

NEW YORK STATE WATER SUPPLY COMMISSION. 6th Annual Report. 1910. *Albany, 1911.* Gift of the commission.

PACIFIC COAST GAS ASSOCIATION. Proceedings. Vol. 8. 1909–1910. Gift of the association.

PITTSBURGH TRANSPORTATION PROBLEM, REPORT ON. By B. J. Arnold, December 1910. *Pittsburgh, 1910.* Gift of the author.

PRACTICAL GAS ENGINEER. By E. W. Longanecker, ed. 8. *1910.*

PRINCETON UNIVERSITY. Catalogue 1910–1911. *Princeton, 1910.* Gift of the university.

REMARKS ON MR. JOHN FITCH'S REPLY TO MR. JAMES RUMSEY'S PAMPHLET. By Joseph Barnes. *Philadelphia, 1788.*

STANDARD METHODS OF TESTING AND SPECIFICATIONS FOR CEMENT. *1909.* Gift of the Association of American Portland Cement Manufacturers.

SYRACUSE UNIVERSITY. April 1911. (University Number.) *Syracuse, 1911.* Gift of the university.

TEMPERATURE ENTROPHY DIAGRAM. By C. W. Berry, ed. 3. *New York, J. Wiley & Sons, 1911.*

Text Book of the Elements of Machine Work. By R. H. Smith. *Boston, Industrial Education Book Co., 1910.*

Text Book of the Principles of Machine Work. By R. H. Smith. *Boston Industrial Education Book Co., 1910.* (Gift of the authors.)

Treatise on the Application of Steam. By James Rumsey. *Philadelphia, 1788.*

U. S. Interstate Commerce Commission. 3d Annual Report of the Block Signal and Train Control Board, 1910. *Washington, 1911.* Gift of the commission.

University of Oklahoma. Research Bulletin No. 4, 1910. *Norman, 1910.* Gift of the university.

University of Pennsylvania. Proceedings of "University Day," February 22, 1911. *Philadelphia, 1911.* Gift of the university.

Washington State Inspector of Coal Mines. Report, 1910. *Olympia, 1911.* Gift of Washington Coal Mine Inspector.

Western Railway Club. Official Proceedings. Feb., May, Sept. 1889; April, Nov. 1890; Oct–Dec. 1893; Jan–May, Sept. 1894; Jan–May 1896. Jan–Feb., Apr–May, 1897. *Chicago, 1889–1897.* Gift of the club.

EXCHANGES

American Gas Institute. Proceedings, Vol. 5, 1910. *New York, 1911.*

American Society of Civil Engineers. Transactions. Vol. 71. 1911. *New York, 1911.*

Smithsonian Institution. Annual Report. 1909. *Washington, 1910.*

Societe Ingenieurs Civils de France. Annuaire, 1911. *Paris, 1911.*

UNITED ENGINEERING SOCIETY

Buildings of Reinforced Concrete. By Chas. Derleth, Jr. Paper before the 34th annual meeting of the Fire Underwriters Association of the Pacific, January 11–12, 1910. Gift of the author.

Förslag till en Svea Kanal. By C. C. Engström. 1–2. *Stockholm, 1908, 1910.* Gift of the author.

Foundations for the Municipal Building, New York. By Maurice Deutsch. Reprinted from School of Mines Quarterly, Vol. 32, No. 1. Gift of the Foundation Company, New York.

Massachusetts State Forester. 7th Annual Report, 1910. *Boston, 1911.* Gift of Massachusetts State Forester.

Meter Code of the Association of Edison Illuminating Companies. 1910. *New York, 1910.* Gift of the association.

Nebraska State Railway Commission. 3d Annual Report. 1910. *Nebraska.* Gift of the commission.

Publishers' Trade List Annual. 1910. *New York, 1910.*

Reference Catalogue of Current Literature. Vols. 1–3, 1910. *London, New York, 1910.*

South Carolina Railroad Commission. 32d Annual Report. 1910. *Columbia, 1911.*

Standard Specifications for Structural Steel, etc. 1910. Gift of Carnegie Steel Company.

TRADE CATALOGUES

The Bristol Co., *Waterbury, Conn.* Bull. no. 127, Bristol's Class 3 recording thermometer for temperatures between 60 deg. and 800 deg. fahr., 39 pp.; Bull. no. 131, Bristol's recording voltmeters for direct and alternating current, 43 pp.

Cincinnati Gasket and Packing Co., *Cincinnati, O.* The latest gaskets 12 pp.

Davis-Bournonville Co., *New York.* Oxy-acetylene welding and cutting apparatus, 32 pp.; leaflets and cuts illustrating welds made, 50 pp.; Autogenous Welding, February 1911. A magazine devoted to welding and cutting, 15 pp.

Lewis M. Ellison, *Chicago, Ill.* Ellison power plant instruments, 32 pp.

Fiske & Co., *Boston, Mass.* Tapestry brick fire places of various designs, 35 pp.

General Electric Co., *Schenectady, N.Y.* Bull. no. 4787, wires and cables, 73 pp.; Bull. no.4806, electric fans and small power motors, 12 pp.; Index to Bulletins, February 1911, 8 pp.; Bull. no. 4791, feeder voltage regulators, 23 pp.; Bull. no. 4799, waterwheel driver alternators, 11 pp.; Bull. no. 4800, indirect current motors, type CVC, 22 pp.; Bull. no. 4811, drum controllers for individual service, 11 pp.; Bull. no. 4812, small direct-current generators, belted, type CVC, 10 pp.; Bull. no. 4813, type *F* form *P* oil break switches for pole line service, 3 pp.; Bull. no. 4817, G. E. 211 railway motor, 18 pp.

Goldschmidt Thermit Co., *New York.* Reactions, 1st Quarter, 1911, devoted to the science of aluminothermics, 20 pp.

Guarantee Construction Co., *New York.* Economic handling and storage of coal and ashes in power plants.

Harrington & King Refrigerating Co., *Chicago, Ill.* Blue prints of perforated articles made, 36 pp.; perforated metals, brass and tin plate, 8 pp.; standard diagonal slot screens, 16 pp.

Johns-Manville Co., *Cleveland, O.* J. M. Roofing Salesman, March 1911, devoted to advertising of roofing, 8 pp.; J. M. Packing Expert, March 1911, published in the interest of perfect packing, 4 pp.

Lehigh Clutch Co., *Catasauqua, Pa.* Friction clutches, 8 pp.

Thomson Electric Welding Co., *Lynn, Mass.* Electric welding machines, 32 pp.

Waterbury Co., *New York.* The simultaneous installation of seven high tension submarine cables, 16 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

084 High class electrical engineer, age about 30, as office partner to consulting mechanical engineer with office in New York.

085 Good operating machine shop superintendent for factory in Springfield, Mass., manufacturing electric magnetos for automobile and gas engine ignition. Experience and ability to design to certain extent jigs, fixtures, templates, etc. Will be principally concerned in taking care of manufacturing end of business and in charge of actual manufacture. Location, Massachusetts.

086 Research engineer wanted. An old established well organized and successful company, manufacturing high class product, desires to secure the services of a practical man well trained in research work, preferably an industrial chemist of large general experience in analysis and testing of materials used in manufacturing, to undertake work of research engineer, specializing and becoming an authority on line of materials including copper, lead and tin alloys, felt, lubricants, explosives, paper, water-proofing, etc., with view to the improvement and extension of product. Man under 40 years of age preferred. Applicants are requested to give their experience in full; state age, positions occupied, and furnish list of references. To the right man permanent position is assured, at liberal salary. Location, Connecticut. (Reply by letter, addressed 086 Am.Soc.M.E.)

087 Works manager wanted. Old established and well organized company, employing about 1000 men, and manufacturing a high class product, wishes to secure a capable works manager of large experience in the production of small and accurate mechanisms, such as adding machines, typewriters, firearms, etc. Man under 40 years of age preferred. Applicants are requested to give their experience in full; state age, positions occupied, and furnish list of references. To the right man a permanent position is assured at liberal salary. Location New York State. (Reply by letter, addressed 087 Am.Soc.M.E.)

088 To take responsible position on staff of management in old established manufacturing concern employing from 80 to 100 men. Present owner technical graduate desires associate to join, taking equal interest, capable of holding leading position in matters pertaining to introduction of modern methods of scientific management and cost finding. Must be able to invest $35,000.

089 Turbine pump designer; must be competent engineer with extensive experience on highest grade turbine pump construction and designing. Location, Middle West.

090 Large concern located near New York City would like to secure services of technically trained draftsman who has had experience in designing paper cutting machines.

091 Factory manager of large manufacturing concern needs an assistant. Must be a technical graduate with several years' experience, progressive, and familiar with scientific shop methods. Twenty-five miles from New York.

092 Designer of automatic machinery, tools, jigs, fixtures; man with shop experience. Location, New Jersey.

093 Engineer for one year's contract, west coast of Africa, 3 deg. north of the equator, erecting and operating gas engine units of 1000 h.p.; must be capable of handling suction and pressure gas producers, knowledge of steam and electric pumps and air compressors.

094 Foundry foreman for yellow brass work, one working at present with concern manufacturing plumbers brass goods preferred. Executive ability required. Rapidly growing and strictly up-to-date plant; location, Delaware.

095 Technical graduate with at least four years' experience as assistant superintendent of electrical cable plant. Must have executive ability, be able to handle men and be thoroughly conversant with common electrical transmission problems.

096 Engineer wanted by chemical company, technical graduate with several years' practical experience in the design and supervision of mechanical installations in power plant and factories.

MEN AVAILABLE

199 Mechanical and structural engineer, wide experience in charge of design of furnace and rolling mills, general steel plant construction. Desires position as chief draftsman or assistant engineer.

200 Associate, at present assistant professor of mechanical engineering in one of the leading engineering colleges in the East, wishes employment for the period from May 10 to September 10. Experienced in testing and erecting power plant machinery and designing steam and gas engines. Would accept moderate salary for a position in designing or testing any kind of power plant machinery.

201 Electrical and mechanical engineer, 17 years' manufacturing, commercial and engineering experience, desires an executive position with manufacturing concern. Experienced in design of manufacturing plants and product; electric railway project work, modern methods of systematizing, cost and other accounting and factory management.

202 Engineer and salesman, gas engineer with electrical department of railroad lines in San Francisco; investigation of fuel resources and preparation of reports on costs of construction and operation of different types of large power and gas plants; desires position as engineer or salesman with by-product coke oven business. $3000 per year to start.

203 Mechanical engineer, technical graduate, eight years' general engineering and executive experience, operation, maintenance, design and manufacture. Desires position as superintendent, chief engineer, works manager, or assistant.

204 Mechanical engineer desires opening as sales engineer or a business connection with manufacturing firm. Age 27, college graduate, two years' experience as sales engineer. At present, erecting shop foreman with large locomotive works.

205 Member, with 15 years' experience in civil and mechanical engineering, especially hydraulics and steam engineering, desires teaching or commercial position.

206 Student member, thorough business and academic training, expects to graduate in mechanical engineering in June. Desires position with consulting engineer or engineering company. Experienced in erecting and testing engines for leading engine building company, manager of automobile garage, experimental engineering corps large steel works, also as assistant instructor in experimental engineering in college. Best of references furnished. Understands machine designing and has made special study of architecture.

207 Construction engineer, up to date on steam, electric power plants, water works, sewer systems for large industrial works, steam, water and electric cable distribution, substations, illumination, high voltage electric motor drives, gas producer plants, letting contracts and superintending work; age 33, technical graduate, married. Salary to begin, $2400.

208 Young engineer, Junior member, ten years' practical experience gas and gasoline engines. Desires position with engineering firm as superintendent of installation or charge of marine or stationary plants, or as sales manager.

209 Member, graduate Cornell, M.M.E. 1900, experienced in power generation, electric transmission and railway electrification, New York, Pacific Coast and Canada. At present, professor of electrical engineering. Wide experience in organization and business management.

210 Mechanical and civil engineer, age 30. Eight years' experience in design, construction and operation of waterworks, power plants and general construction work. Open for engagement May 18. At present in Southwest. Permanent position desired.

211 Graduate engineer with nine years' experience responsible positions in construction, operating and other departments of various industries, desires association of similar nature in vicinity of Philadelphia or New York.

212 Graduate mechanical engineer, Mass. Inst. Tech., three years' teaching engineering subjects; two years in practical work in New York. At present engaged in research work for degree of M.M.E. Desires position as professor in steam engineering.

213 Junior member, technical education, 15 years' experience, steam and oil engines, tools, hydraulic and general machinery. Four years' chief draftsman, one, shop foreman. At present employed designing special machinery. Age 33; desires position within commuting distance from Orange, N. J.

214 Associate; 15 years' experience on blast furnaces, steel, rolling, pipe and tube mills, coke ovens and chemical apparatus, as draftsman, squad foreman and checker, desires to locate in the East, preferably near Philadelphia.

215 Member desires to connect with manufacturing, contracting or engineering firm in position requiring progressive business ability as well as technical capacity. Wide experience in mechanical lines and some electrical, from drafting to supervision; sales engineer during past three years. Technical graduate 34 years of age.

216 Member; at present occupying an executive position with large machinery manufacturer, desires an engagement with either the manufacturing or selling departments of a live concern; engines, turbines, electrical machinery, power transmission or similar lines.

217 Graduate mechanical engineer, nine years' general experience with air compressor builders, design, testing, development of electric driven units, special problems in air and natural gas compression, sales engineering and publicity work; wants responsible position with compressor builders. At present employed.

218 Member desires position as engineer, chief draftsman or designer; 20 years' experience in various lines, as chief draftsman or mechanical engineer; experience in printing and other paper handling machinery.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALEXANDER, Ludwell Brooke (Junior,1905), Asst. Genl. Sales Mgr., Bosch Magneto Co., 223 W. 46th St., and Cliffwood Court, 179th St. and Ft. Washington Ave., New York, N. Y.

ANGSTROM, C. Jonas (1908), 3706 Bates St., Pittsburg, Pa.

ANGUS, Robert (1891), Cons. Engr., 705 Confederation Life Bldg., Toronto, Ont., Canada.

BACON, Charles James (1905; 1907), Steam Engr., Ill. Steel Co., South Chicago, and 7334 Palmer Ave., Chicago, Ill.

BALTZELL, Willie Harry (1910), Ch. Engr., Pittsburg Crucible Steel Co., Oliver Bldg., Pittsburg, Pa.

BANTA, Earle Jackson (1907), 105 Avenida Juarez, Mexico, D. F., Mex.

BEMENT, A. (1901), Cons. Engr., 206 S. La Salle St., and 2927 Warren Ave., Chicago, Ill.

BENNETT, Geo. G. (Junior, 1903), Efficiency Engr., Ludlow Mfg. Associates, and *for mail*, P. O. Box 75, Ludlow, Mass.

BIXBY, William P. (Junior, 1908), Union Wadding Co., Pawtucket, R. I.

BLAND, John P. (1901), Printer and Ch. Engr., The Times, and *for mail*, 48 Thurleigh Rd., Nightingale Lane, London, S. W., England.

BLUM, Joseph K. (Junior, 1909), Mech. Engr., Coplay Cement Mfg. Co., and *for mail*, 146 Central Park W., New York, N. Y.

BORDEN, Wm. H. (Junior, 1905), Box 189, Valdez, Alaska.

BOWERMAN, Myron Ralph (Junior, 1910), 2126 S. Central Park Ave., Chicago, Ill.

BROWN, Walter Ellsworth (Junior, 1910), Supt., Middleby Auto Co., and *for mail*, 806 N. 9th St., Reading, Pa.

BUSH, Harold Montfort (1894; 1905), Cons. Engr., 508 Capitol Trust Bldg., Columbus, and Briggsdale, O.

CARPENTER, Allan O. (Associate, 1909), Designing Dept., Ingersoll Rand Co., Painted Post, and *for mail*, 1 E. Pulteney St., Corning, N. Y.

COOK, John P. (Junior, 1906), 260 B Manning Blvd., Albany, N. Y.

COOK, William Henry (Junior, 1910), Am.Loco. Co., Cooke Wks., and *for mail* 56 18th Ave., Paterson, N. J.

CORK, Robert L. (Junior, 1907), Ch. Engr., Almont Mfg. Co., Almont, Mich.

COX, Frederick W. (1908), P. O. Box 496, Carson City, Nev.

CRAIG, James (1897), Mech. Engr., 807–841 Garfield Ave., Jersey City, N. J.

CRAIGHEAD, Magruder (Junior, 1910), Link-Belt Co., 131 State St., Boston, Mass.

CROGHAN, John T. (Associate, 1909), Stone & Webster Engrg. Corp., Plymouth Bldg., Minneapolis, Minn.

CUNNINGHAM, George H. (Junior, 1910), Consolidation Coal Co., Jewel, Ky

ERGUSON, Hardy Smith (1899), Cons. Engr., 200 Fifth Ave., New York, N. Y., and 82 Pine St., Portland, Me.

GAST, George Fred (Junior, 1910), Constr. Dept., Minnesota & Ontario Power Co., International Falls, and *for mail*, 2027 Oakland Ave., Minneapolis, Minn.

GERNANDT, Waldo George (Junior, 1910), Designer, Carriage Chassis Dept., Packard Motor Car Co., Detroit, Mich.

GREEN, Wm. O. (1891), Member of Firm, Ogden, Sheldon & Co., 192 N. Clark St., and 1211 Astor St., Chicago, Ill.

HILL, Reuben (1908), Supt., Detroit Lubricator Co., Detroit, Mich.

HOWELLS, Charles (1904), Box 164, Washingtonville, N. Y.

LANE, Francis W. (Associate, 1900), Engrg. Corr., London Times, Editor, Natl. Land and Irrigation Journal 30 S. Market St., amd *for mail*, 6438 Normal Ave., Chicago, Ill.

LATTA, Nisbet (Junior, 1902), V. P., Wisconsin Engine Co., Corliss, Wis.

LEE, Francis V. T. (1907), Cons. Engr., care of The Royal Colonial Inst., Northumberland Ave., London, W. C., England, and University Club., San Francisco, Cal.

LENT, Leon B. (1905), Ch. Engr., N. Y. Blaugas Co., Brewster, N. Y.

McDEVITT, Frank J. (Junior, 1906), Dist. Mgr., Elliott Co., and Liberty Mfg. Co. of Pittsburg, Pa., 351 Pierce Bldg., St. Louis, Mo.

McJILTON, John Perkins (Junior, 1910), Draftsmen, Loco. Superheater Co., 30 Church St., and *for mail*, 153 E. 86th St., New York, N. Y.

MAYSILLES, John Henry (1901; 1910), Supt., Davenport Loco. Wks., Davenport, Ia.

MORRISON, Clarke J. (1909), Effective Organization Dept., Suffern & Son, 165 Broadway, New York, N. Y., and *for mail*, 191 N. Walnut St., East Orange, N. J.

MOWERY, John N. (1906), M. M., N. Y. N. H. & H. R. R., Waterbury, Conn.

NICHOLS, Charles H. (1908), Cons. Engr., 1133 Broadway, and 63 W. 127th St., New York, N. Y.

PAUL, Charles Edward (1908), Assoc. Prof. Mechanics, Armour Inst. of Tech., and *for mail*, 6238 Ellis Ave., Chicago, Ill.

PENNOCK, George Alger (Junior, 1903), Asst. Supt., Service and Maintenance, Western Elec. Co., Hawthorne, Ill.

POTTS, S. Warren (1909), Mech. Engr., R. Hoe & Co., 504 Grand St., and *for mail*, 622 W. 135th St., New York, N. Y.

RANDALL, Dwight T. (1904), 70 Smith Ave., Detroit, Mich.

RIGGS, John D. (Junior, 1892), Ch. Draftsman, Oliver Chilled Plow Wks., and *for mail*, Genl. Delivery, South Bend, Ind.

SCOTT, J. Alvah (1900), Naval Arch. and Marine Engr., Ossining-on-Hudson, N. Y.

SHALLCROSS, Watson Comly (1910), Solvay Process Co., Detroit, Mich.

SHEPERDSON, John Wm. (Associate, 1908), Asst. Supt., Gautier Dept., Cambria Steel Co, and *for mail*, 126 Tioga St., Westmont, Johnstown, Pa.

SMITH, George Marshall (Associate, 1904), V. P. and Treas., A. E. Anderson & Co., 642 Prudential Bldg., Buffalo, N. Y., and 4632 N. Winchester Ave., Chicago, Ill.

STUTZ, C. C. (1900), Cons. Engr., 3830 Forest Ave., Norwood, O.

THRELFALL, William V. (1902), Textile Mchy., Mill and Power Equip., Marshall Bldg., 40 Central St., Boston, Mass.

WATSON, Henry D. (1897; 1900), East. Sales Mgr., Saurer Motor Co., 30 Church St., New York, and 136 E. 19th St., Flatbush, Brooklyn, N. Y.

WHITE, Herbert J. (1909), Wks. Mgr. and Mech. Engr., Krantz Mfg. Co., and *for mail*, 439 Eighth St., Brooklyn, N. Y.

WILLIAMSON, Leroy A. (Associate, 1902), Pres., L. A. Williamson Co., 258 Broadway, New York, N. Y.

WILSON, Robert Alexander (Junior, 1910), Constr. Engr., Snow Steam Pump Wks., Buffalo, N. Y.

WILSON, William L. (Junior, 1907), V. P., The Elec. Installation Co., 411 N. Charles St., Baltimore, Md.

WINTZER, Rudolph (1908), 685 Farwell Ave., Milwaukee, Wis.

WOLDENBERG Izydor (Junior, 1903), Dir. Ingersoll-Rand Co., m.b.H., Oststrasse 128–132, Düsseldorf, Germany.

WOOD, Thomas C. (Junior, 1909), 359 St. John's Pl., Brooklyn, N. Y.

WRIGHT, Wm. Quinby (1908), Min. and Civ. Engr., 727 Merchants Exch. Bldg., San Francisco, and Sausalito, Cal.

ZIMMERMAN, Oliver B. (1905), Engr., E. Burner & Co., South Bend, Ind.

NEW MEMBERS

CUMMINS, Peter Augustine (Junior, 1910), Special Apprentice, Shop Practice, Detroit Steel Products Co., and *for mail*, 30 Hazelwood Ave., Detroit, Mich.

DAVOCK, Harlow N. (Junior, 1910), 79 Garfield Ave., Detroit, Mich.

FIELD, Freeman (Associate, 1910), V. P. and Treas., Sheffield Gas Power Co., Kansas City, Mo.

NELSON, Bernard Stanley (Junior, 1910), Head Draftsman, A. M. Lockett & Co., and *for mail*, 533 Baronne St., New Orleans, La.

DEATHS

BROOKS, Paul Raymond, March, 11, 1911.
CALDWELL, George B., March 31, 1911.
HAMMARBERG, Arndt L., February 7, 1911.
HART, Frederick L., March 23, 1911.
HUNT, Charles Wallace, March 27, 1911.
WHITE, Everett H., January 12, 1911.
WILSON, Dwight Boyden, March 7, 1911.

GAS POWER SECTION

CHANGES OF ADDRESS

BARKER, John H. (Affiliate, 1908), Mgr., N. Y. Office, Diehl Mfg. Co., 90 Prince St., New York, and *for mail*, 466 E. 7th St., Brooklyn, N. Y.
BRENNAN, Daniel Aloysius (Affiliate, 1910), Designer and Erector, Wisconsin Eng. Co., Corliss, and *for mail*, 375 Superior St., Milwaukee, Wis.
CRAIG, James (1910), Mem.Am.Soc.M.E.
HOWELLS, Charles (1909), Mem.Am.Soc.M.E.
LATHROP, Jay Cowden (Affiliate, 1908), Iowa Traction Co., Oskaloosa, Ia.
LENT, Leon B. (1908), Mem.Am.Soc.M.E.
RANDALL, Dwight T. (1910), Mem.Am.Soc.M.E.
SHORKEY, Edward Louis (Affiliate, 1909), Gas Eng. Dept., Bethlehem Steel Co., and *for mail*, Leonard Hall, South Bethlehem, Pa.
WILSON, Robert Alexander (1909), Mem.Am.Soc.M.E.
ZIMMERMAN, Oliver B. (1908), Mem.Am.Soc.M.E.

NEW MEMBER

ONUKI, Riojo (Affiliate, 1910), Yokosuka Naval Dock Yard, Yokosuka, Japan.

STUDENT BRANCHES

CHANGES OF ADDRESS

BONNELL, W. W. (Student, 1910), 715 South Ave., Wilkinsburg, Pa.
CADY, Cecil I. (Student, 1909), care of The Sanitary Water Still Co., Jamaica, N. Y.
CAMPBELL, C. P. (Student, 1911), 245 Ramona St., Palo Alto, Cal.
COOK, G. C. (Student, 1909), 200 W. 81st St., New York, N. Y.
CRANE, Fred. L. (Student, 1909), The Westinghouse Club, Wilkinsburg, Pa.
CUMMINS, G. F. (Student, 1910), 3412 S. Park Ave., Chicago, Ill.
FAIRCHILD, F. P. (Student, 1910), 575 68th Ave., Milwaukee, Wis.
JEHLE, Ferdinand (Student, 1909), Genl. Motors Co., Detroit, Mich.
JOHNSON, C. E. (Student, 1909), 534 Madison St., Topeka, Kan.
PAGE, Wilsen K. (Student, 1909), 202 S. Union St., Olean, N. Y.
RICHARDSON, Lawrence (Student, 1909), 1704 Seventh Ave., Altoona, Pa.
RUGG, D. M. (Student, 1909), 540 Madison St., Gary, Ind.
SELDEN, G. D., Jr. (Student, 1911), 124 Sheff. Vanderbilt, New Haven, Conn.
SWIGGETT, C. A. (Student, 1909), 304 W. Madison St., Iola, Kan.
THOMPSON, Wm. H. (Student, 1909), 53 N. 13th St., Newark, N. J.
WILES, F. S. (Student, 1910), Syracuse, Neb.

NEW MEMBERS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

BREWSTER, E. W. (Student, 1911), Tech. Chambers, Irvington St., Boston, Mass.
CUSTER, L. L. (Student, 1911), 76 Huntington Ave., Boston, Mass.
HALL, Edward R. (Student, 1911), 1 Davis St., Wollaston, Mass.
NOYES, J. A. (Student, 1911), 124 Adams St., Waltham, Mass.

STEVENS INSTITUTE OF TECHNOLOGY

SKINNER, B. C. (Student, 1911), 1233 Bloomfield St., Hoboken, N. J.

UNIVERSITY OF MISSOURI

HECKER, A. J. (Student, 1911), 10 Lathrop Hall, Columbia, Mo.
HEPTONSTALL, A. E. (Student, 1911), 108 College Ave., Columbia, Mo.

COMING MEETINGS

MAY—JUNE

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AIR BRAKE ASSOCIATION

May 23-26. annual convention, Auditorium Hotel, Chicago, Ill. Papers: Air Brake Instruction, Rating, T. Clegg, Geo. A Wyman, H. H. Burns, H. A. Wahlert, T. F. Lyons; Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, J. P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves without Lubricants, L. Leonard; Fibre Stresses in Brake Gear Parts, G. O. Hammond; "P. C." Equipment, W. V. Turner; Steel Pipe vs. Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down, G. R. Parker, H. A. Wahlert, N. A. Campbell, J. R. Alexander; Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, A. S. Williamson; Breaking-in-two of Trains, S. H. Draper, P. J. Langan. Secy., F. M. Nellis, 53 State St., Boston, Mass.

AMERICAN ASSOCIATION OF REFRIGERATION

May 9-10, annual meeting, La Salle Hotel, Chicago, Ill. Secy., J. F. Nickerson, 431 S. Dearborn St.

AMERICAN FOUNDRYMEN'S ASSOCIATION
AMERICAN BRASS FOUNDERS' ASSOCIATION
ASSOCIATED FOUNDRY FOREMEN

May 23-26, annual convention, Pittsburg, Pa. Papers: Production Cost, Economic Foundry Insurance, Uniform Contracts, Unloading Methods, Use of Borings in Cupolas, Effect of Alloys in Cast Iron, Permanent Molds, Vanadium in Non-Ferrous Alloys, Determination of Nickel Bronzes, Pouring High Grade Bronzes, Rotary Blowers, Foundry Construction, Heating and Lighting Systems, Pattern Making, Molding Machines, Acid and Basic Open-Hearth Processes, Electric and Converter Furnaces for Steel Castings, Effect of Vanadium and Titanium on Steel, Corrosion of Brass Foundry Products, Pyrometer and the Aluminum Foundry, Non-Ferrous Foundry Economies, Equilibrium Diagrams, Molding Sand, Use of Alloys, Shot in Castings. Secy., Richard Moldenke, Watchung, N. J.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

June 21-24, annual meeting, Chicago, Ill. Reports by committees on Chemical Engineering Education and Standardization of Boiler Tests. Secy., J. C. Olsen, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

May 16, monthly meeting, 29 W. 39th St., New York. Annual convention, last of June, Chicago, Ill. Secy., R. W. Pope, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF MINING ENGINEERS

June 6, Glen Summit meeting, Glen Summit Springs Hotel, Glen Summit Springs, Pa. Secy., Dr. Joseph Struthers, 29 W. 39th St., New York.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

June 14–16, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN RAILWAY INDUSTRIAL ASSOCIATION

May 9–10, annual meeting, Detroit, Mich. Secy., Guy L. Stewart, 1328 Pierce Bldg., St. Louis, Mo.

AMERICAN SOCIETY FOR TESTING MATERIALS

June 27–30, annual meeting, Atlantic City, N. J. Secy., Edgar Marburg, Univ. of Penn., Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS

June 13–16, annual meeting, Chattanooga, Tenn. Secy., C. W. Hunt, 220 W. 57th St., New York.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS

Monthly meetings: May 9, 29 W. 39th St., New York; May, 17, Boston, Mass. Spring Meeting, May 30–June 2, Pittsburg, Pa. Secy., Calvin W. Rice, 29 W. 39th St., New York.

AMERICAN WATER WORKS ASSOCIATION

June 6–10, annual convention, Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charlestown, S. C.

CANADIAN GAS ASSOCIATION

June 22–24, annual meeting, Quebec City, Quebec. Secy., John Keillor, Hamilton, Ont.

INTERNATIONAL MASTER BOILER MAKERS' ASSOCIATION

May 23–26, annual convention, Omaha, Neb. Secy., Harry D. Vought, 95 Liberty St., New York.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

May 15–18, annual convention, Hotel Patten, Chattanooga, Tenn. Papers: Fuel Investigations under the Bureau of Mines, J. A. Holmes, Mem.Am. Soc.M.E.; How to Organize a Railway Fuel Department and Its Relation to other Departments, T. D. Smith; The Testing of Locomotive Fuel, F. O. Bunnell; Standard Locomotive Fuel Performance Sheet, F. C. Pickard; The Railway Fuel Problem in Relation to Railway Operation, R. Emerson; Petroleum, Its Origin, Production and Use as Locomotive Fuel, E. McAuliffe. Secy., D. B. Sebastian, 721 La Salle Station, Chicago, Ill.

IRON AND STEEL INSTITUTE

May 11–12, annual meeting, Institution of Civil Engineers, Great George Street, Westminster, London, S. W., England. Papers: On Temperature Influences on Carbon and Iron, E. Adamson; On the Chemical and Mechanical Relations of Iron, Chromium and Carbon, J. O. Arnold, A. A. Read; On the Growth of Cast Irons after Repeated Heatings, H. C. H. Carpenter; On the Relation of Impurities to the Corrosion of Iron, J. W. Cobb; On Magnetic Properties of some Nickel Steels with some notes on the Structures of Meteoric Iron, E. C. Glauert, S. Hilpert; Notes on a Process for the Dessication of Air by Calcium Chloride, F. A. Baubinè, E. V. Roy; On the Volumetric Estimation of Sulphur in Iron and Steel, T. G. Elliot; On the Action of Aqueous Solutions of single and mixed Electrolytes on Iron, J. N. Friend, J. H. Brown; On Iron-Silicon-Carbon Alloys, W. Gontermann; On the Influence of Vanadium upon Cast Iron, W. H. Hatfield; On the Organic Origin of the Sedimentary Ores of Iron, W. H. Herdsman; On Some Studies on Welds, E. F. Law, W. H. Merrett, W. P. Digby; On the Corrosion of Steel, P. Longmuir, On the Influence of 2 Per Cent of Vanadium on Steels of Varying Carbon Content, A McWilliam, E. J. Barnes; On Some Properties of Heat-Treated 3 Per Cent Nickel Steels, A. McWilliam, E. J. Barnes; On Mechanicalising Analysis as an Aid to Accuracy and Speed for Commercial Purposes, C. H. Ridsdale, N. D. Ridsdale; On Welding up of Blowholes and Cavities in Steel Ingots, J. E. Stead. Secy., G. C. Lloyd, 28, Victoria Street, London, S. W., England.

MASTER CAR BUILDERS' ASSOCIATION

June 19-21, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION

May 29–June 2, annual convention, New York. Secy., T. C. Martin, 29 W. 39th St.

NATIONAL FIRE PROTECTION ASSOCIATION

May 23–25, annual meeting, New York. Secy., F. H. Wentworth, 87 Milk St., Boston, Mass.

NATIONAL GAS AND GASOLINE ENGINE TRADES ASSOCIATION

June 20–23, Spring Convention, Detroit, Mich. Secy., Albert Stritmatter, Cincinnati, O.

OHIO SOCIETY OF MECHANICAL, ELECTRICAL AND STEAM ENGINEERS

May 18–19, semi-annual meeting, Youngstown, O. Secy., Frank E Sanborn, Ohio State University, Columbus, O.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

June 27–29, annual convention, Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

SOCIETY OF AUTOMOBILE ENGINEERS

June 15–17, midsummer meeting, Dayton, O. Genl. Mgr., Coker F. Clarkson, 1451 Broadway, New York.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
May			
4	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
9	American Society of Mechanical Engineers	C. W. Rice	8.15 p.m.
11	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
11	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
16	New York Telephone Society	T. H. Lawrence	8.15 p.m.
16	American Institute of Electrical Engineers	R. W. Pope	8.15 p.m.
17	American Railway Association	W. F. Allen	10.00 a.m.
19	New York Railroad Club	H. D. Vought	8.15 p.m.
22	National Isolated Power Plant Association	E. D. Fieux	8.00 p.m.
24	Municipal Engineers of New York	C. D. Pollock	8.15 p.m.
30–June 2	National Electric Light Association	T. C. Martin	all day
June			
1	Blue Room Engineering Society	W. D. Sprague	8 p.m.
8	Illuminating Engineering Society	P. S. Millar	8 p.m.
8	Institute of Operating Engineers	M. W. Rice	8 p.m.
20	New York Telephone Society	T. H. Lawrence	8.15 p.m.
26	National Isolated Power Plant Association	E. D. Fieux	8 p.m.

OFFICERS AND COUNCIL

PRESIDENT

E. D. Meier	New York

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Charles Whiting Baker	New York
W. F. M. Goss	Urbana, Ill.
Alex. C. Humphreys	New York

Terms expire at Annual Meeting of 1911

George M. Brill	Chicago, Ill.
E. M. Herr	Pittsburg, Pa.
H. H. Vaughan	Montreal, Can.

Terms expire at Annual Meeting of 1912

MANAGERS

H. L. Gantt	New York
I. E. Moultrop	Boston, Mass.
W. J. Sando	Milwaukee, Wis.

Terms expire at Annual Meeting of 1911

H. G. Stott	New York
James Hartness	Springfield, Vt.
H. G. Reist	Schenectady, N.Y.

Terms expire at Annual Meeting of 1912

D. F. Crawford	Pittsburg, Pa.
Stanley G. Flagg, Jr.	Philadelphia, Pa.
E. B. Katte	New York, N. Y.

Terms expire at Annual Meeting of 1913

PAST-PRESIDENTS

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M. L. Holman	St. Louis, Mo.
Jesse M. Smith	New York
George Westinghouse	Pittsburg, Pa.

TREASURER

William H. Wiley	New York

CHAIRMAN OF THE FINANCE COMMITTEE

Robert M. Dixon	New York

HONORARY SECRETARY

F. R. Hutton	New York

SECRETARY

Calvin W. Rice	29 West 39th Street, New York

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W. L. Saunders (5)

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Edward Van Winkle (3)
Bernard V. Swenson (1)
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S. D. Collett (5)

LIBRARY

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E. G. Spilsbury (5)

MEETINGS

L. R. Pomeroy (1), *Chairman*
H. de B. Parsons (3)
Chas. E. Lucke (2)
Willis E. Hall (4)
C. J. H. Woodbury (5)

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Francis H. Stillman (1), *Chairman*
Hosea Webster (3)
George J. Foran (2)
Theo. Stebbins (4)
W. H. Boehm (5)

PUBLICATION

H. F. J. Porter (1), *Chairman*
Geo. I. Rockwood (3)
Fred R. Low (2)
Geo. M. Basford (4)
Chas. I. Earll (5)

PUBLIC RELATIONS

James M. Dodge, (5), *Chairman*
D. C. Jackson (2)
Robert W. Hunt (1)
J. W. Lieb, Jr. (3)
Fred J. Miller (4)

RESEARCH

W. F. M. Goss (3), *Chairman*
Ralph D. Mershon (2)
R. H. Rice (1)
Jas. Christie (4)
R. C. Carpenter (5)

Note.—Numbers in parentheses indicate number of years the member has yet to serve.

SPECIAL COMMITTEES

1911

On a Standard Tonnage Basis for Refrigeration

D. S. Jacobus
G. T. Voorhees
A. P. Trautwein
Philip De C. Ball
E. F. Miller

On Society History

John E. Sweet
H. H. Suplee

On Constitution and By-Laws

Jesse M. Smith
F. R. Hutton
G. M. Basford
D. S. Jacobus

On Conservation of Natural Resources

Geo. F. Swain, *Chairman*
L. D. Burlingame
Charles Whiting Baker
M. L. Holman
Calvin W. Rice

On Identification of Power House Piping

H. G. Stott, *Chairman*
H. P. Norton
I. E. Moultrop
J. T. Whittlesey
F. R. Hutton

On International Standards for Pipe Threads

E. M. Herr, *Chairman*
Geo. M. Bond
William J. Baldwin
Stanley G. Flagg, Jr.

On Standards for Involute Gears

Wilfred Lewis, *Chairman*
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Hugo Bilgrim
C. R. Gabriel
Gaetano Lanza

On Power Tests

D. S. Jacobus, *Chairman*
Edward T. Adams
George H. Barrus
L. P. Breckenridge
William Kent
Charles E. Lucke
Edward F. Miller
Arthur West
Albert C. Wood

On Standardization of Flanges

A. C. Ashton
J. P. Sparrow
Wm. Schwanhausser
H. G. Stott

On Student Branches

F. R. Hutton, Honorary Secretary

Tellers of Election Officers and Members

Wm. T. Donnelly
Geo. A. Orrok
Theo. Stebbins

Nominating Committee Officers 1912

R. C. Carpenter, *Chairman*, New York
A. M. Hunt, San Francisco, Cal.
R. H. Fernald, Cleveland, O.
E. G. Spilsbury, New York
C. J. H. Woodbury, Boston, Mass.

MEETINGS OF THE SOCIETY

THE COMMITTEE ON MEETINGS

L. R. Pomeroy, (1) *Chairman*
H. de B. Parsons (3)
Chas. E. Lucke (2)
Willis E. Hall(4)
C. H. J. Woodbury (5)

Meetings of the Society in Boston

Ira N. Hollis, *Chairman*
I. E. Moultrop, *Secretary*
Edward F. Miller
James D. Andrew
Richard H. Rice

Meetings of the Society in New York

Walter Rautenstrauch, *Chairman*
Fredk. A. Waldron, *Secretary*
F. H. Colvin
Edward Van Winkle
Roy V. Wright

Meetings of the Society in St. Louis

Ernest L. Ohle, *Chairman*
Fred E. Bausch, *Secretary*
M. L. Holman
R. H. Tait
John Hunter

Meetings of the Society in San Francisco

A. M. Hunt, *Chairman*
T. W. Ransom, *Secretary*
W. F. Durand
E. C. Jones
Thomas Morrin

Meetings of the Society in Philadelphia

Thomas C. McBride, *Chairman*
D. R. Yarnall, *Secretary*
A. C. Jackson
J. E. Gibson
W. C. Kerr
J. C. Parker
James Christie

SUB-COMMITTEES OF COMMITTEE ON MEETINGS

On Machine Tools

Willis E. Hall, *Chairman*
John Parker Ilsley
Walter Rautenstrauch

On Economic Administration of Industrial Establishments

Chas. B. Going, *Chairman*
James Hartness
C. U. Carpenter
Worcester R. Warner

Mechanical Engineering of Textile Industry

Charles T. Plunkett, *Chairman*, Adams, Mass.
Daniel M. Bates, Wilmington, Del.
Franklin W. Hobbs, Boston, Mass.
John Eccles, Taftville, Conn.
C. R. Makepeace, Providence, R. I.
Edw. W. France, Philadelphia, Pa.
C. H. Manning, Manchester, N. H.
Edward F. Greene, Boston, Mass.
Henry P. Mansfield, Utica, N. Y.
Edward W. Thomas, Lowell, Mass.
C. J. H. Woodbury, Boston, Mass.

SOCIETY REPRESENTATIVES

1911

On John Fritz Medal

F. R. Hutton (1)
Henry R. Towne (3)
John A. Brashear (4)

On Board of Trustees United Engineering Societies Building

Fred J. Miller (1)
Jesse M. Smith (2)
Alex. C. Humphreys

On National Fire Protection Association

John R. Freeman
Ira H. Woolson

On Joint Committee on Engineering Education

Alex. C. Humphreys
F. W. Taylor

On Advisory Board National Conservation Commission

Geo. F. Swain
John R. Freeman
Chas. T. Main

On Council of American Association for the Advancement of Science

Alex. C. Humphreys

International Association for Testing Materials
Committee on Nomenclature of Iron and Steel

Charles Kirchhoff

Note.—Numbers in parentheses indicate number of years the member has yet to serve.

OFFICERS OF THE GAS POWER SECTION

1911

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R. H. Fernald

SECRETARY
Geo. A. Orrok

GAS POWER EXECUTIVE COMMITTEE

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E. D. Dreyfus (1)
F. R. Hutton (2)
H. H. Suplee (3)
F. R. Low (4)

GAS POWER MEMBERSHIP COMMITTEE

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A. F. Stillman
G. M. S. Tait
George W. Whyte
S. S. Wyer

GAS POWER MEETINGS COMMITTEE

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Nisbet Latta
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S. O. Sandell
S. I. Oesterreicher
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	1908			
Stevens Inst. of Tech., Hoboken, N. J.	December 4	Alex. C. Humphreys	W. G. H. Brehmer	J. G. Bainbridge
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	1909			
Armour Inst. of Tech., Chicago, Ill.	March 9	G. F. Gebhardt	C. E. Beck	F. H. Griffiths
Leland Stanford Jr. University, Palo Alto, Cal.	March 9	W. R. Eckart	H. H. Blee	E. L. Ford
Polytechnic Institute, Brooklyn, N. Y.	March 9	W. D. Ennis	A. L. Palmer	R. C. Ennis
Purdue University, Lafayette, Ind.	March 9	L. V. Ludy	L. Jones	H. E. Sproull
University of Kansas, Lawrence, Kan.	March 9	P. F. Walker	W. H. Judy	M. C. Conley
New York Univ., New York City	November 9	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois, Urbana, Ill.	November 9	W. F. M. Goss	F. J. Schlink	E. J. Hasselquist
Penna. State College, State College, Pa.	November 9	J. P. Jackson	W. E. Heibel	G. M. Forker
Columbia University, New York City	November 9	Chas. E. Lucke	F. T. Lacy	J. L. Haynes
Mass. Inst. of Tech., Boston, Mass.	November 9	Gaetano Lanza	J. A. Noyes	R. M. Ferry
Univ. of Cincinnati, Cincinnati, O.	November 9	J. T. Faig	H. B. Cook	C. J. Malone
Univ. of Wisconsin, Madison, Wis.	November 9	H. J. B. Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri, Columbia, Mo.	December 7	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska, Lincoln, Neb.	December 7	C. R. Richards	W. J. Wholenberg	W. H. Burleigh
	1910			
Ulv. of Maine, Orono, Me.	February 8	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas, Fayetteville, Ark.	April 12	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University, New Haven, Conn.	October 11	L. P. Breckenridge	ClaytonDuBosque	W. St. C. Childs
Rensselaer Poly. Inst., Troy, N. Y.	December 9	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
	1911			
State Univ. of Ky., Lexington, Ky.	January 10	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University, Columbus, O.	January 10	W. T. Magruder	H. A. Shuler	H. M. Bone
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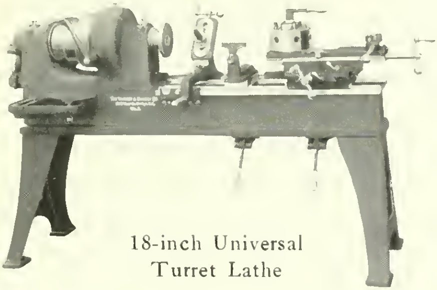

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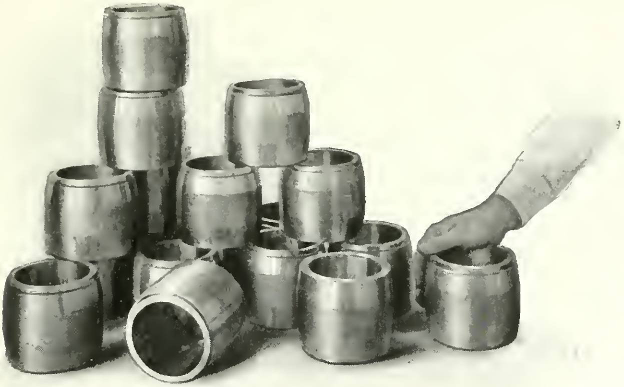

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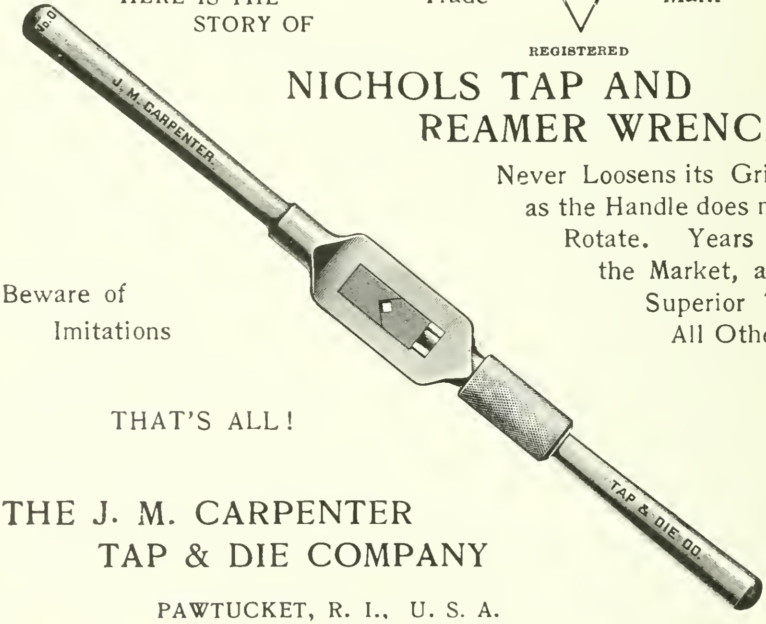

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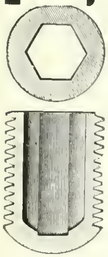

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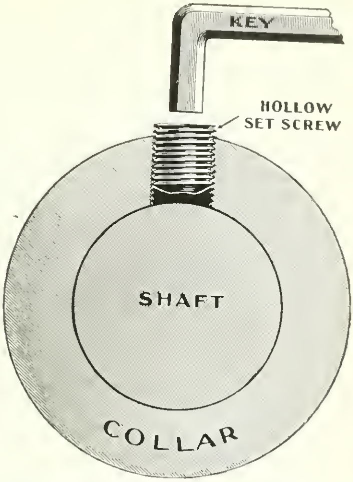

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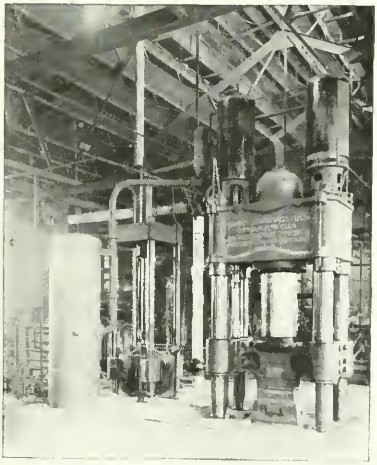

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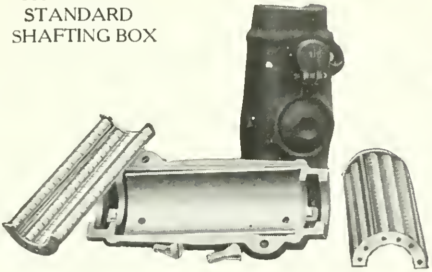

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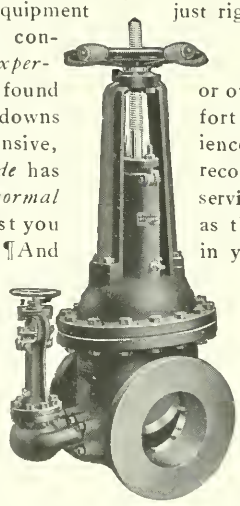

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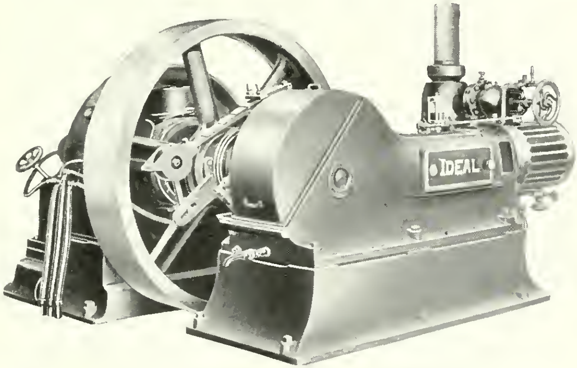

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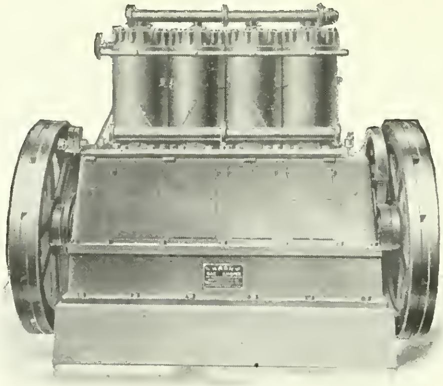

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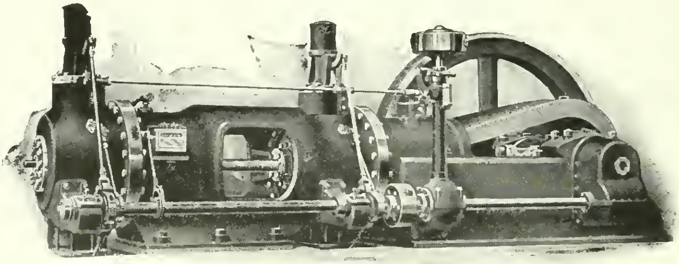

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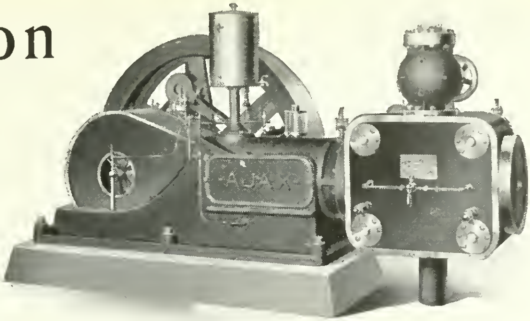

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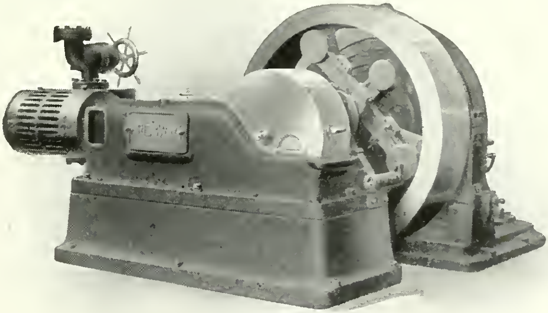

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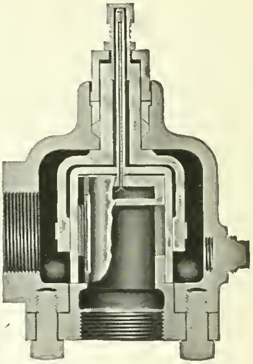

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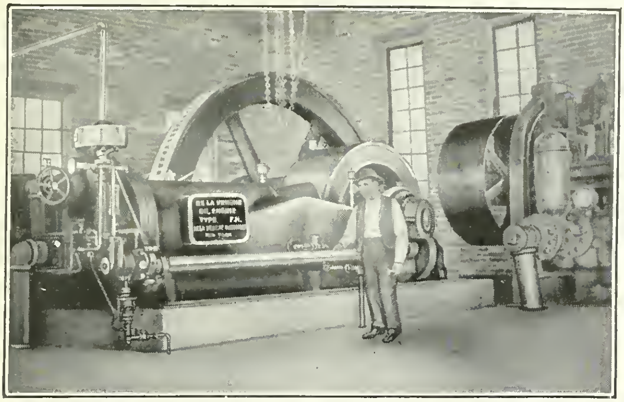

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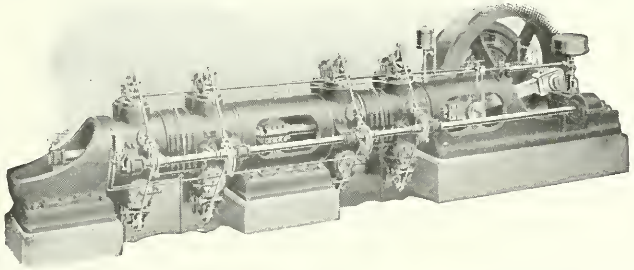

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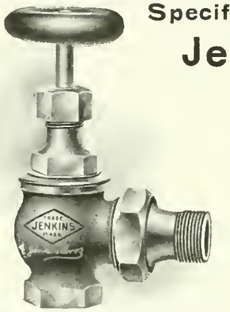

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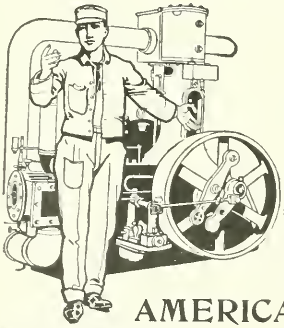

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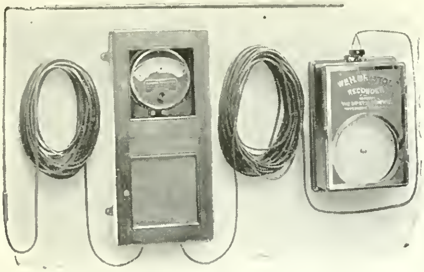

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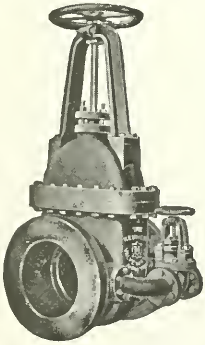

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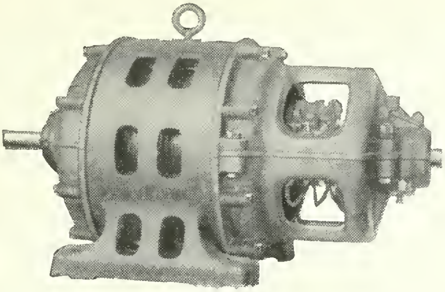

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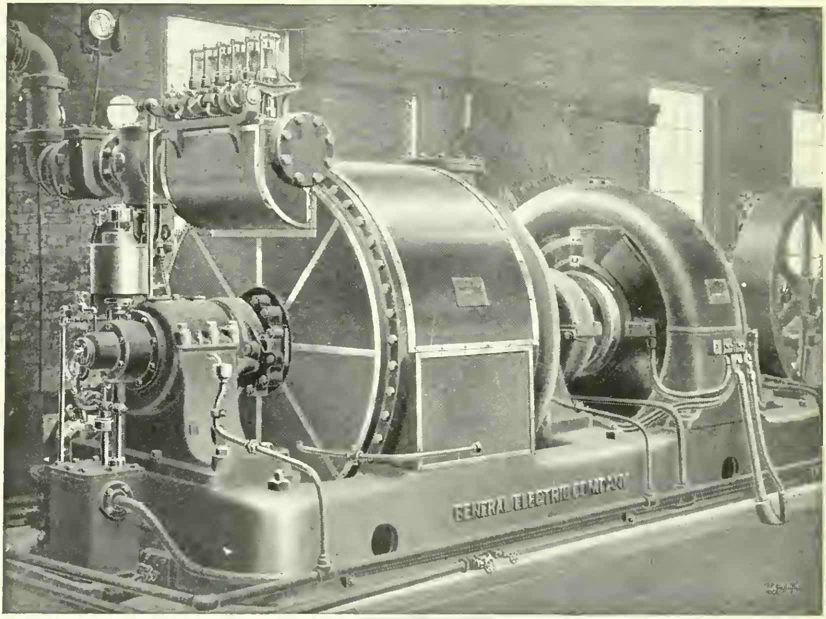

Curtis Horizontal Steam Turbines

In Coal Mine Power Plants

The Davis Coal and Coke Co. of Thomas, W. Va., has installed a 500 kw. Curtis Horizontal Steam Turbine, as illustrated above. This machine carries the widely fluctuating loads of mine locomotives and motors.

Two additional Curtis Turbines of 1000 kw. each will soon be added to this plant.

Where continuity and reliability of service must be maintained under severe operating conditions, Curtis Turbines are constantly demonstrating their superiority.

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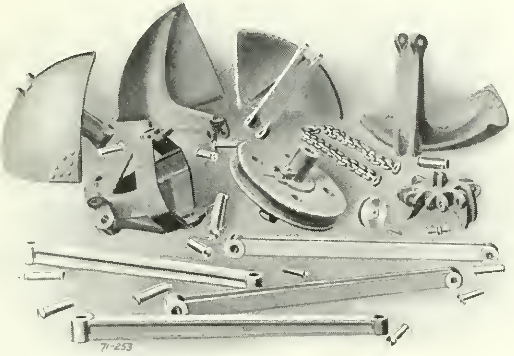
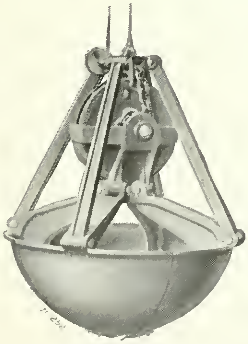
MANUFACTURING COMPANY



Component parts of Orange Peel Bucket

GRAB BUCKETS

The Mead-Morrison Orange Peel Grab combines a minimum of working parts with maximum durability, efficiency and capacity. The period of its service is prolonged indefinitely through the use of renewable bronze bushings and renewable steel digging points. Its use is a permanent economy.



Mead-Morrison Grabs are also made in Clam Shell and Special Types.

Correspondence invited.

General Offices and Works,
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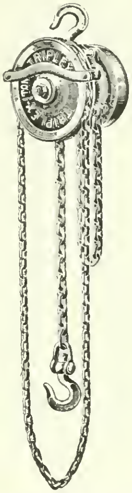
NEW YORK, 149 Broadway; CHICAGO, Monadnock Block; BALTIMORE, 821 Equitable Bldg.; PITTSBURG, 108 Parkway, N. S.; SAN FRANCISCO, Metropolis Bank Bldg.; NEW ORLEANS, 110 North Peters Street; MONTREAL, 286 St. James St.

THE TRIPLEX BLOCK

When You Buy a Chain Block, Buy It Wisely



FOR the efficiency, durability and safety of a chain block, you must rely on the machine the maker sells you.

Guarantees don't count—materials, workmanship and tests are the things that tell.

We were the pioneers in chain block manufacture. All that is known in regard to building chain blocks was developed in our works.

Forty years of experience has taught us how to design, build and sell them.

When you buy a Triplex Block you are buying the result of all our experience,—something that cannot be bought anywhere else in the world.

The Yale & Towne Mfg. Co.

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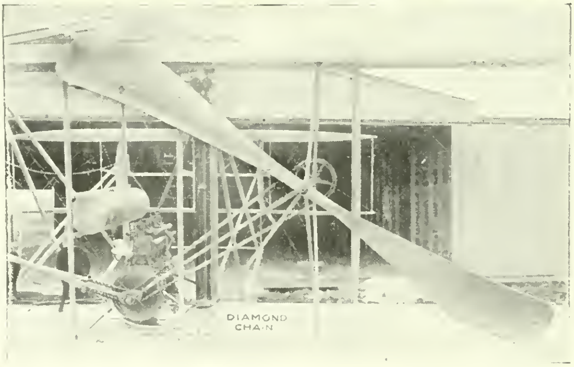

A TRYING SERVICE BUT DIAMOND CHAINS HAVE MADE GOOD

After much experimenting the Wright Brothers chose Diamond Chain as the best medium for transmitting power from the engine to propellers on their biplanes.

This is splendid proof of the real merit of Diamond Chains for aviators can't afford to take chances. The driving chains like all other parts of such a machine must be absolutely dependable, regardless of cost. If you have a hard problem for chain driving, you will be well repaid by investigating *Diamond Chains first.* Better to start with Diamond than come to them later.

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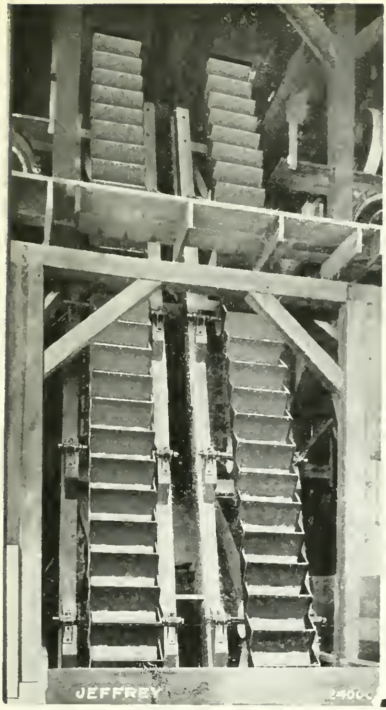
259 W. GEORGIA ST. **INDIANAPOLIS, IND.**

Capacity 8,000,000 feet per year



Jeffrey Elevators

For handling Coal, Stone, Ore, etc., are absolutely dependable and can be adapted to meet all practical requirements.

View shows two Continuous Bucket Elevators 65 feet high between centers, handling stone at a large crushing plant.

Conveyers, Screens, Crushers, Dump Cars, Coal and Ashes Handling Machinery for Power Plants, Industrial Locomotives, Chains of all kinds.

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The Jeffrey Mfg. Company

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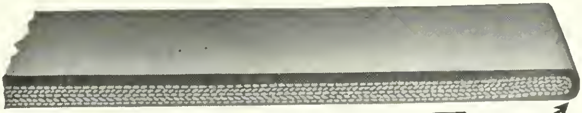
Conveyor Belt User

Have you had trouble with the Edge of Your Belt?
Does it come loose, peel, break off, or wear away?
Then let your next belt be a

Goodrich Conveyor Belt



Edge Construction—Goodrich Conveyor Belt

This is the best edge ever put on a conveyor belt. Notice how the top cover is carried around into the back cover without leaving a thin corner to break loose. No square corners to catch. No molded edge to peel off. The edge is formed by a special process of our own and is vulcanized before the rest of the belt so that the adhesion of the corner around the edge is as perfect as elsewhere. This edge cover stays on until worn off and thus protects the fabric from the entrance of moisture which quickly deteriorates the whole belt and causes the thick top cover to peel off. *We make a good belt with a real edge.*

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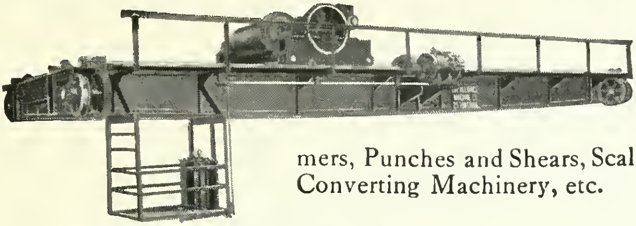

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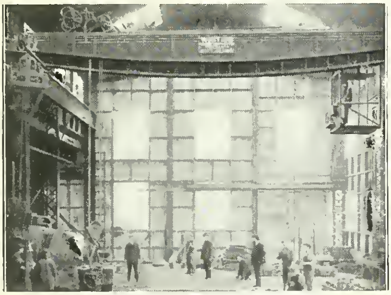

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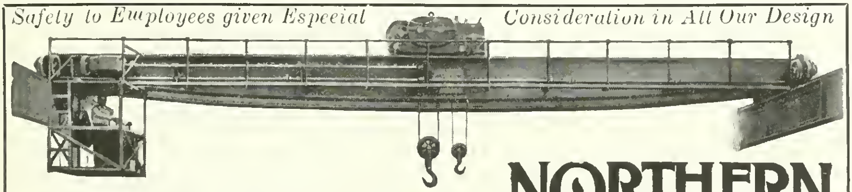

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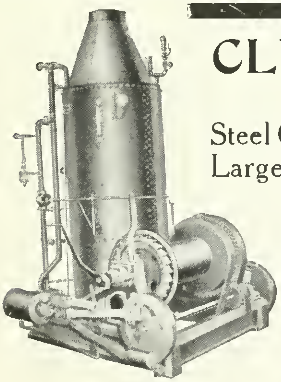

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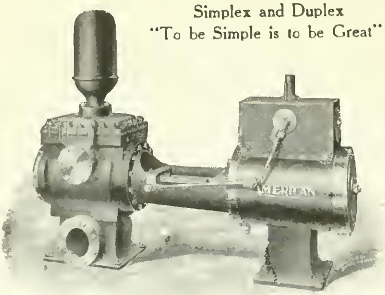

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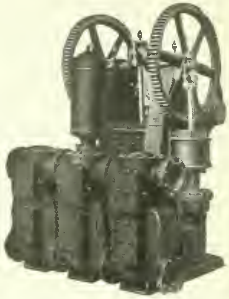

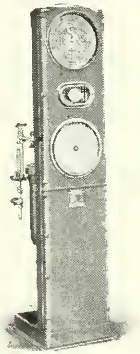

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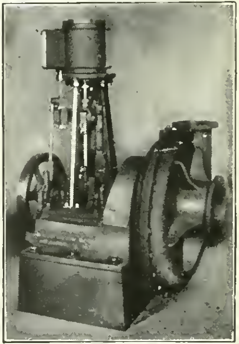

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THE
JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

JUNE 1911

SPRING MEETING, PITTSBURG, MAY 30—JUNE 2.
MONTHLY MEETINGS: PHILADELPHIA, JUNE 3;
SAN FRANCISCO, JUNE 28.

JUNE 1911 VOL. 33 No. 6

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 JUNE 1911 NUMBER 6

SPRING MEETING, PITTSBURG, MAY 30-JUNE 2

The Spring Meeting of The American Society of Mechanical Engineers, to be held at Pittsburg, Pa., May 30 to June 2, 1911, will have a program of exceptional professional interest, supplemented by technical excursions and social gatherings, which should make it one of the most valuable as well as enjoyable conventions ever held by the Society. The professional sessions have as usual been arranged by the Committee on Meetings, while all other events are in charge of the Local Committee, E. M. Herr, Chairman.

The headquarters of the convention will be the Hotel Schenley and the professional sessions will be held at the Carnegie Institute, in close proximity to the hotel.

PROGRAM

Tuesday Morning and Afternoon, May 30

Registration at headquarters at the Hotel Schenley.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Tuesday Evening, 8.30

Informal reception for the members and ladies of the Society in the parlors of the Hotel Schenley.

PROFESSIONAL SESSION

Business meeting. Reports of Tellers of Election and Committees. New Business.

Wednesday, May 31, 10 a.m.

MECHANICAL ENGINEERING OF CEMENT MANUFACTURE

Some Problems of the Cement Industry, Walter S. Landis.
The Edison Roll Crushers, W. H. Mason.
Power and Heat Distribution in Cement Mills, L. L. Griffiths.

Wednesday Afternoon

Excursion by special train to the plant of the Universal Portland Cement Company, Universal, upon invitation of Mr. E. M. Hagar, President.

The train will stop at East Pittsburg, both going and returning, to permit those who desire to inspect the works of the Westinghouse Electric & Manufacturing Company and the Westinghouse Machine Company.

Inspection of the Foundry and Machine Exhibition Company's Exhibit at Exposition Building.

Wednesday Evening, 8.30

SESSION ON MACHINE SHOP PRACTICE

The Assembly of Small Interchangeable Parts, John Calder.
The Process of Assembling a Small and Intricate Machine, Halcolm Ellis.
Quantity Manufacture of Small Devices, F. P. Cox.
Milling Cutters and Their Efficiency, A. L. De Leeuw.

GAS POWER SESSION

Business meeting, followed by discussions constituting a symposium on Large Gas Power Plants. A. E. Maccoun of the Carnegie Steel Company will open the discussion and will be followed by representatives of the leading firms building large gas engines and producers.

A pamphlet has been prepared by W. E. Snyder of the American Steel and Wire Company, for distribution at the meeting, illustrating and describing the principal gas power plants in the Pittsburg district.

THE WORK OF THE U. S. BUREAU OF MINES, S. B. Flagg and C. D. Smith.

Thursday, June 1, 10 a.m.

MISCELLANEOUS SESSION

STRESSES IN TUBES, Reid T. Stewart.
THE PURCHASE OF COAL, D. T. Randall.
ENERGY AND PRESSURE DROP IN COMPOUND STEAM TURBINES, F. E. Cardullo.
THE PRESSURE-TEMPERATURE RELATIONS OF SATURATED STEAM,* L. S. Marks.
PRESSURE RECORDING INDICATOR FOR PUNCHING MACHINERY, G. C. Anthony.

Thursday Afternoon

Excursion up the Monongahela River for members and ladies, including inspection trip to the National Tube Company's works at McKeesport.

Thursday Evening

Reception and dance at the Hotel Schenley for members and ladies.

Friday, June 2, 10 a.m.

SESSION ON STEEL WORKS PRACTICE

COMMERCIAL APPLICATION OF THE TURBINE TURBO-COMPRESSOR, R. H. Rice.
RECIPROCATING BLAST-FURNACE BLOWING ENGINES, W. Trinks.
POWER FORGING WITH SPECIAL REFERENCE TO STEAM-HYDRAULIC FORGING PRESSES, Berthold Gerdau and George Mesta.

Friday Afternoon

Inspection trip to Mesta Machine Company's works at Homestead.

Friday Evening

Smoker and entertainment given in honor of The American Society of Mechanical Engineers by the Engineers' Society of Western Pennsylvania in their rooms in the Oliver Building.

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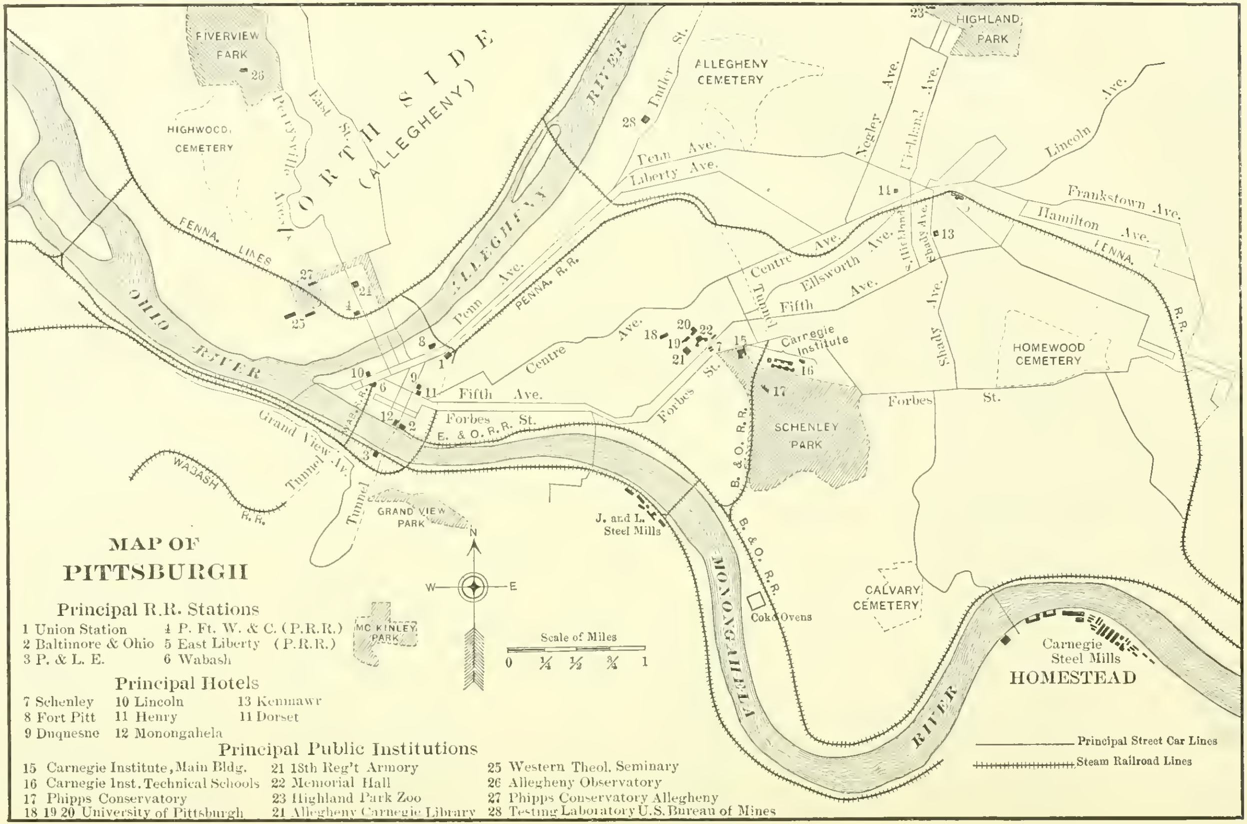
* To be read by title only.


MAP OF PITTSBURGH
Principal R.R. Stations
1 Union Station
2 Baltimore & Ohio
3 P. & L. E.
4 P. Ft. W. & C. (P.R.R.)
5 East Liberty (P.R.R.)
6 Wabash
Principal Hotels
7 Schenley
8 Fort Pitt
9 Duquesne
10 Lincoln
11 Henry
12 Monongahela
13 Kenmawr
11 Dorset
Principal Public Institutions
15 Carnegie Institute, Main Bldg.
16 Carnegie Inst. Technical Schools
17 Phipps Conservatory
18 19 20 University of Pittsburgh
21 18th Reg't Armory
22 Memorial Hall
23 Highland Park Zoo
21 Allegheny Carnegie Library
25 Western Theol. Seminary
26 Allegheny Observatory
27 Phipps Conservatory Allegheny
28 Testing Laboratory U.S. Bureau of Mines
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W
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OHIO RIVER
ALLEGHENY RIVER
MONONGAHELA RIVER
RIVERVIEW PARK
HIGHWOOD CEMETERY
ALLEGHENY CEMETERY
HIGHLAND PARK
HOMEWOOD CEMETERY
SCHENLEY PARK
CALVARY CEMETERY
GRAND VIEW PARK
MC KINLEY PARK
Carnegie Institute
Carnegie Steel Mills
HOMESTEAD
J. and L. Steel Mills
Coke Ovens
Perrysville Ave.
East St.
Butler St.
Penn Ave.
Liberty Ave.
Centre Ave.
Ellsworth Ave.
Fifth Ave.
Forbes St.
Negley Ave.
Highland Ave.
S. Highland Ave.
Shady Ave.
Lincoln Ave.
Frankstown Ave.
Hamilton Ave.
Grand View Av.
Tunnel
PENNA. LINES
PENNA. R.R.
PENNA.
R.R.
B. & O. R.R.
WABASH R.R.

LADIES' PROGRAM

The Ladies' Committee, Mrs. Chester B. Albree, Chairman, have prepared a program for the visiting ladies, which includes the following events, in addition to those scheduled on the general program to which ladies are invited. It is probable that there will be additional features which cannot be announced at this date.

Wednesday Morning, May 31

Inspection of the Margaret Morrison Carnegie School for Women, of the Carnegie Institute.

Luncheon at the Pittsburg Golf Club.

Wednesday Afternoon

Tea at the Twentieth Century Club.

Wednesday Evening

Visit to Annual Exhibit of the Carnegie Art Galleries.

Thursday Morning, June 1

Inspection of Carnegie Institute and the new Athletic Club.

Friday Morning, June 2

Inspection of the Heinz Pickle Works.

Automobile drive through East End Parks.

Friday Afternoon

Automobile drive to Sewickley.

Tea at the Allegheny Country Club.

RAILROAD TRANSPORTATION NOTICE

Arrangements for hotel, transportation and Pullman car accommodations should be made personally.

Special concessions have been secured for members and guests attending the Spring Meeting in Pittsburg, May 30 to June 2, 1911.

The special rate of a fare and three-fifths for the round trip, on the certificate plan, is granted when the regular fare is 75 cents and upwards, from territory specified below.

a Buy your ticket at full fare for the going journey, between May 26 and June 1 inclusive. At the same time request a certificate, *not a receipt.* This ticket and certificate should be secured at least half an hour before the departure of the train.

b Certificates are not kept at all stations. Ask your station agent whether he has certificates and through tickets. If not, he will tell you the nearest station where they can be obtained. Buy a local ticket to that point, and there get your certificate and through ticket.

c On arrival at the meeting, present your certificate to S. Edgar Whitaker, office manager, at Headquarters. A fee of 25 cents will be collected for each certificate validated. No certificate can be validated after June 2.

d An agent of the Trunk Line Association will validate certificates, May 31, June 1, 2. No refund of fare will be made on account of failure to have certificate validated.

e One-hundred certificates and round trip tickets must be presented for validation before the plan is operative. This makes it important to show the return portion of your round trip ticket at Headquarters.

f If certificate is validated, a return ticket to destination can be purchased, up to June 6, on the same route over which the purchaser came, at three-fifths the rate.

The special rate is granted only for the following:

The Trunk Line Association:

All of New York east of a line running from Buffalo to Salamanca, all of Pennsylvania east of the Ohio River, all of New Jersey, Delaware and Maryland;

also that portion of West Virginia and Virginia north of a line running through Huntington, Charleston, White Sulphur Springs, Charlottesville, and Washington, D. C.

The New England Passenger Association except via Eastern Steamship Co.

Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut.

HOW TO REACH PITTSBURG

FROM NEW YORK

Via Pennsylvania Railroad:

	No. 25	No. 43	No. 9	No. 19	No. 37
Lv. New York..	8.04 a.m.	10.04 a.m.	6.04 p.m.	8.30 p.m.	10.08 p.m.
Arr. Pittsburg..	5.52 p.m.	6.55 p.m.	5.55 p.m.	6.30 a.m.	8.00 a.m.

No. 25 dining car from Philadelphia; No. 9 dining car: No. 43 observation dining car: No. 37 dining car.

This company will be glad to make Pullman reservations on application, and its representatives will deliver tickets to members if desired. Address applications to 263 Fifth Avenue, New York.

Via Baltimore and Ohio Railroad:

Lv. New York......................	7.50 a.m.	3.50 p.m.	6.50 p.m.
Arr. Pittsburg.....................	8.50 p.m.	5.55 a.m.	8.05 p.m.

Fare to Pittsburg, $9 for through ticket and $10.50 for ticket allowing stop-over at Philadelphia, Baltimore or Washington. Offices, 434 Broadway, New York.

FROM WESTERN POINTS

Via Pennsylvania Railroad:	No. 16	No. 22	No. 24
Lv. Chicago..........................	8.15 a.m.	10.30 a.m.	8.00 p.m.
Lv. Fort Wayne......................	12.03 p.m.	2.05 p.m.	11.55 p.m.
Arr. Pittsburg......................	8.10 p.m.	9.55 p.m.	8.15 p.m.

	No. 24	No. 30	No. 44	No. 18	No. 14
Lv. St. Louis..	12.40 p.m.	4.30 p.m.	5.00 p.m.	8.15 p.m.	11.35 p.m.
" Indianapolis	7.20 p.m.	10.20 p.m.	11.25 p.m.	3.35 a.m.	8.10 a.m.
" Cincinnati..	9.00 p.m.	....	....	....	7.30 a.m.
" Columbus...	12.40 a.m.	2.35 a.m.	4.05 a.m.	8.55 a.m.	12.50 a.m.
Arr. Pittsburg..	6.05 a.m.	6.55 a.m.	8.45 a.m.	2.30 p.m.	5.50 p.m.

No. 22, all Pullman cars $2 extra fare: No. 30, all Pullman cars $2.50 extra fare.

HOTEL RATES FOR SPRING MEETING AT PITTSBURG

Minimum Rates

	Without Bath			With Bath		
	Single Room	Single Room Two Persons	Double Room Two Persons	Single Room	Single Room Two Persons	Double Room Two Persons
Hotel Schenley	$2.00	$3.00	$——	$3.00	$4 00	$5.00
Fort Pitt Hotel	1.50	——	2.50	2.50	——	3.50
	2.00	——	3.00	5.00		7.00
Hotel Henry	1.50	2.50	3.00	2.50	3.50	4.00
	2.00	up	up	up	up	up
Monongahela House	1.50	——	2.00	2.50	——	4.00
	2.00		3.00	3.00		5.00
Hotel Anderson	1.00	1.50	3.00	2.50	——	4 00
		2.00	4.00	3.50		
Duquesne Hotel	1.50	——	2.50	2.50	——	3.50
Hotel Lincoln	1.50	——	2.00	2.00	——	3.00
	2.50	——	4.00	3.00		5.00
Seventh Avenue Hotel	1.50	2.50	3.00	2.50	4.00	5.00
Colonial Annex Hotel	1.50	2.00	2.50	2.00	3.00	3.50
						5.00
The Dorset	1.00	——	2.00	2.00	——	3.00
Hotel Lorraine*	2.50	——	4.00	3.00	——	5.00
				3.50		6.00

*American plan.

LOCAL COMMITTEE

E. M. Herr, *Chairman*
Elmer K. Hiles, 2511 Oliver Bldg., *Secretary*
George Mesta, Chairman Committee on Finance
John M. Tate, Chairman Committee on Entertainment
Chester B. Albree, Chairman Committee on Hotels
Morris Knowles, Chairman Committee on Printing
D. F. Crawford, Chairman Committee on Transportation
Mrs. Chester B. Albree, Chairman Ladies' Committee

MONTHLY MEETINGS

PHILADELPHIA MEETING, JUNE 3

On account of the interest manifested on the subject of Fuel Testing, considered at the meeting in Philadelphia on April 22, when a paper by J. C. Parker of that city on the Work of the United States Fuel Testing Station was presented, the meeting on June 3 in that city will be given up to further discussion of the same topic. As this will follow immediately after the Spring Meeting in Pittsburg, members passing through Philadelphia will have an opportunity to be present and to take part in the discussion. The Engineers Club of Philadelphia will coöperate in the meeting.

ST. LOUIS MEETING, JUNE 7

The meeting of the Society in St. Louis on June 7 will take the form of a banquet, held at the Mercantile Club in that city under the auspices of the Engineers Club of St. Louis, in which the members of the American Institute of Electrical Engineers, the American Society of Civil Engineers, the American Society of Engineering Contractors, as well as of the Society will participate. Col. E. D. Meier, President, will be the chief speaker of the evening.

SAN FRANCISCO MEETING, JUNE 28

At a meeting of the Society in San Francisco on June 28, the Use of Fuel Oil considered at the meeting of March 10, will receive further discussion. A paper upon the Control of Surges in Water Conduits will be presented by the author, W. F. Durand, professor of mechanical engineering of Stamford University.

PROVIDENCE MEETING, MAY 3

The first meeting of the Society in Providence was held in the West Side Club on May 3, 1911, the Providence Association of Mechanical Engineers coöperating, with an attendance of nearly 200. The Society was officially represented by Col. E. D. Meier, President, F. R. Hutton, Honorary Secretary, and Calvin W. Rice, Secretary. At the conclusion of an informal reception in the parlors of the club the guests sat down to a banquet in the large dining hall. Edwin C. Bliss, Mem. Am. Soc. M. E. and President of the Providence Association of Mechanical Engineers, gave an address of welcome, outlining briefly the history of the Providence association and dwelling somewhat upon the work done by it in inaugurating in Providence the half-time course of industrial education for machinists. The toastmaster of the evening, Williams Howard Paine, was then introduced and paid a high tribute to the many natives of Providence who had become prominent in the mechanical field, including Robert Henry Thurston, Past President, Am.Soc.M.E., George H. Corliss, Noble T. Greene, Lucian Sharpe, and a number of others.

In response to the toast, The American Society, Calvin W. Rice said that this inauguration of affiliation meetings meant much to the engineering profession, and described in some detail how the Society carries on its work. He was followed by Col. E. D. Meier who, in replying to the toast, The Affiliation of the Two Societies, told of the advantages such an affiliation would bring and gave a brief outline of the organization and growth of the various engineering societies of the country, showing that while the early tendency was toward specialization and segregation, the present movement was directed to affiliation.

The final speaker of the evening, F. R. Hutton, gave a short address upon Safety Appliances, dividing his subject into three topics, what is an accident, who is to prevent accidents, and is the prevention of accidents not practicable. He claimed that accidents were of two classes, preventable and non-preventable, and by the aid of nearly 100 lantern slides described the means that are being taken in this country and abroad to protect the employees from accidents of all kinds.

NEW YORK MEETING, MAY 9

At the monthly meeting of the Society in New York, on May 9, the subject of Patent Law was considered, with papers on the More Fundamental Principles of Patent Law, by Edwin J. Prindle, Letters Patent for Inventions, by D. Howard Haywood, and the Patent Expert, by E. W. Marshall, dealing with the question of patent rights and the protection they afford, and with the method of securing the benefits of the patent law as well as of avoiding its abuses. The papers were discussed by A. Parker Smith, lawyer and patent expert, New York, Frank M. Ashley, patent attorney and consulting engineer, New York, and W. S. Rogers, president of the Bantam

Anti-Friction Company of Bantam, Conn. A written discussion was presented by Alonzo B. See, of the A. B. See Electric Elevator Company, New York.

BOSTON MEETING, MAY 17

A meeting of the Society was held in Boston on May 17 in coöperation with the Boston Society of Civil Engineers and the Boston Section of the American Institute of Electrical Engineers, the program of the evening being in charge of the latter organization. A paper on the Electric Motor in the World's Work was presented by the author, Fred. M. Kimball, Assoc.A.I.E.E., Manager of the small motor department of the General Electric Company, West Lynn, Mass., in which he briefly described the development of the electric motor from the discovery of the fundamental principles early in the nineteenth century up to the present time. He exhibited a large number of lantern slides showing the very diversified application of the motor to various industries. On account of the character and length of the paper there was no discussion. About 150 attended the meeting, which was the final one of a very successful series held in Boston during the season 1910–1911.

BILL FOR LICENSING ENGINEERS

The committee of engineers appointed to deal with the subject of the bill for licensing engineers, Col. E. D. Meier, President Am.Soc. M.E., Chairman, Alfred P. Boller, R. S. Buck, C. W. Baker, Mem. Am.Soc.M.E., George B. Francis, E. G. Spilsbury, Mem.Am.Soc.M. E., and Frank J. Sprague, has ascertained that no further action is likely to be taken upon this bill at this session of the legislature.

ADDRESS BY THE PRESIDENT AT N. A. C. M. MEETING

At the annual meeting of the National Association of Cotton Manufacturers held in Boston, Mass., April 12–13, 1911, Col. E. D. Meier represented the Society and spoke briefly of the relation of the mechanical engineer to the cotton industry. At the close of the meeting the following resolution was adopted:

Resolved, that the thanks of this Association be expressed to Col. E. D. Meier, President of The American Society of Mechanical Engineers, for his contribution which added so much to the pleasure of the meeting.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

At a meeting of the Columbia University Student Branch, April 21, L. De G. Moss gave an interesting talk on the value of studying engineering in its various branches. Election of officers for the school year, 1911–1912, resulted as follows: N. E. Hendrickson, president; E. Mosher, vice-president; Mr. Ruprecht, secretary; Mr. Stone, treasurer.

OHIO STATE UNIVERSITY

A special meeting of the Ohio State University Student Branch was held April 10 and a paper on Steam Turbines was presented by Mr. McClelland. The regular monthly meeting at which a paper on Smoke Prevention, by Mr. Griffin was read, was held April 20. The subject aroused general interest and a liberal discussion followed the reading.

PENNSYLVANIA STATE COLLEGE

The Student Branch of the Pennsylvania State College held a meeting, April 25, at which a paper on The Manufacture of Locomotive Tires by C. E. Dahl was presented.

PURDUE UNIVERSITY

Theodore Weinshank, Mem.Am.Soc.M.E., addressed the meeting of the Purdue University Student Branch on April 19, his subject being Types of Feed Water Heaters and Purifiers. The discussion was illustrated by lantern slides and many practical and instructive points were brought out by the speaker. On May 3, the meeting was addressed by H. S. Dickerson on the subject of the Indicator Optique, or manograph, recently invented by O. Schulze.

STATE UNIVERSITY OF KENTUCKY

At a meeting of the State University of Kentucky Student Branch, April 25, J. B. Stanwood, Mem.Am.Soc.M.E., lectured on Special Features of Slide Valve Engines, devoting most of his attention to some experimental work in connection with the leakage of a balanced slide valve which has given excellent results. The work that the leaf spring-governor can do in moving a valve was discussed in detail, as well as the four valve engine design, using a slide valve for the admission, and Corliss valves for the exhaust. Other papers presented were: Efficient Advertising of Machinery, Theodore Slade; a discussion of the papers by W. S. Landis, Some Problems of the Cement Industry, and Milling Cutters and their Efficiency, by A. L. DeLeeuw, Mem.Am.Soc.M.E. Prof. J. E. Tuthill gave a talk on The Value of History to the Engineer.

STEVENS INSTITUTE OF TECHNOLOGY

On April 25, the Stevens Institute of Technology Student Branch held its closing meeting of the year. A. E. Bauhan was elected president of the society for next year; R. T. Branch, vice-president; A. D. Karr, secretary and O. E. Röesen, treasurer. The paper of the evening was Rotary Converter Sub-Station by A. E. Bauhan. Among the points treated were the growth and development of the sub-station, its location and requirements, its economic features and general layout, its specific layout to meet local conditions and demands, and a detailed description of the apparatus. The paper was discussed by Messrs. Mitchill, Requa, Schaefer and Stern.

UNIVERSITY OF CINCINNATI

On April 28 at a meeting of the University of Cincinnati Student Branch, papers on Alternating Current vs. Direct Current, by H. B. Cook, and Scientific Time Setting, by G. W. Binns, were presented. A general discussion by the members followed the reading of each paper.

UNIVERSITY OF MISSOURI

At the April 19 meeting of the University of Missouri Student Branch two papers published by the Society were presented and discussed: Commercial Application of the Turbo-Compressor, R. H. Rice and The Purchase of Coal, D. T. Randall. Professors Hibbard, Mem.Am.Soc.M.E., and Fessenden, Jun.Am.Soc.M.E., Messrs. Kennedy and Thacher discussed the papers. On May 1, the paper by S. B. Fowler, The Mechanical Handling of Freight, was read. The following took part in the discussion: Professors Hibbard Fessenden, Wharton, Westcott and Messrs. Thacher, Edgar, Dunbar.

UNIVERSITY OF WISCONSIN

At a meeting of the University of Wisconsin Student Branch, May 11, a paper on The Constructing Engineer was presented by Mr. Reed, formerly constructing engineer with the Arnold Company, Chicago, Ill. R. S. Hoyt also presented a paper, The Engineer, in which the aims, ideals, work and standards of the profession were considered.

YALE UNIVERSITY

A meeting of the Yale University Student Branch was held May 12 and a paper on The Essential Requirements as to Sewage Disposal, by George W. Fuller was presented. The paper touched on the nature of sewage, its relation to public water supplies, requirements for satisfactory disposal works, need of careful management, the hygienic, financial and sentimental aspect of the problem.

REPORT OF COMMITTEE ON IDENTIFICATION OF POWER HOUSE PIPING

a In the main engine rooms of plants which are well lighted, and where the functions of the exposed pipes are obvious, all pipes shall be painted to conform to the color scheme of the room; and if it is desirable to distinguish pipe systems, colors shall be used only on flanges and on valve fitting flanges.

b In all other parts of the plant, such as boiler house, basements, etc., all pipes (exclusive of valves, flanges and fittings), except the fire system, shall be painted black, or some other single, plain, durable, inexpensive color.

c All fire lines (suction and discharge), including pipe lines, valve flanges and fittings, shall be painted red throughout.

d The edges of all flanges, fittings or valve flanges on pipe lines larger than 4 in. inside diameter, and the entire fittings, valves and flanges on lines 4 in. inside diameter and smaller, shall be painted the following distinguishing colors, numbered 1 to 12, inclusive:

DISTINGUISHING COLORS TO BE USED ON VALVES, FLANGES AND FITTINGS ONLY

Steam division	*a* High pressure—white
	b Exhaust system—buff
Water division	*c* Fresh water, low pressure—blue
	d Fresh water, high pressure boiler feed lines—blue and white
	e Salt water piping—green
Oil division	*f* Delivery and discharge—brass or bronze yellow
Pneumatic division	*g* All pipes—gray
Gas division	*h* City lighting service—aluminum
	i Gas engine service–black, red flanges
Fuel oil division	*j* All piping—black
Refrigerating system	*k* White and green stripes alternately on flanges and fittings, body of pipe being black
Electric lines and feeders	*l* Black and red stripes alternately on flanges and fittings, body of pipe being black

Respectfully submitted,
F. R. Hutton
I. E. Moultrop
H. P. Norton
J. T. Whittlesey
H. G. Stott, *Chairman*

NECROLOGY

ALEXANDER E. BROWN

Alexander E. Brown was born in Cleveland, December 14, 1852, and was educated at grammar and high schools there. He was graduated from the Brooklyn Polytechnic Institute in 1872 as a civil engineer. Immediately after graduation Mr. Brown joined the U. S. Geological Survey under F. P. Haven. Until November 1872 he was engaged in the exploration and location of the Yellowstone National Park. During the next two years he served as chief engineer of the Massillon Iron Bridge Company, Massillon, O., where he obtained his first real experience in the iron business. From 1875 to 1879 he was engaged in bridge and building construction as engineer, designer and contractor. He later acted as superintendent at iron mines in the Lake Superior iron region and gained experience also in blast furnace work. In 1875 he invented and patented new machines and processes for annealing malleable iron castings, which are still in use at the National Malleable Iron Castings Company. In 1878 Mr. Brown became mechanical engineer for the Brush Electric Company then known as the Cleveland Electric Supply Company. While with this concern he developed the process and method of manufacturing light carbons. Still later he worked with Chas. F. Brush in developing and placing on the market the Brush arc lighting system. In 1879, Mr. Brown took up the problem of the rapid and economical unloading and handling of iron ore from boats. A year later he took out patents on the Brown hoisting and conveying machines erected on the docks of the N. Y., P. & O. Ry. Co., now part of the Erie system. He then organized the Brown Hoisting and Conveying Machinery Company for the manufacture of his machines. For the past 30 years Mr. Brown spent most of his time designing and manufacturing machinery for the handling of different machines. He had taken out several hundred patents on his various inventions.

He took an active interest in the development of trade schools in Cleveland, and was one of the directors of the Training School Company, organized in 1885, to open a carpenter shop for boys to which pupils were to be admitted free for a course extending over three years. He was a member of the American Institute of Mining Engineers, the Society of Naval Architects and Marine Engineers, Civil Engineers Club, Electric Engineers Club of Cleveland, the Engineers Club of New York and the Chamber of Commerce of Cleveland. He died April 26, 1911.

ON THE CONTROL OF SURGES IN WATER CONDUITS

By W. F. Durand

ABSTRACT OF PAPER

The usual treatment of the problem of the surge chamber presupposes a cylindrical form. Certain cases may arise in which a flaring or funnel-shaped form may rather be preferred. In any case the differential equations which indicate the movement of the water do not admit of direct mathematical solution. In consequence, various indirect and approximate methods have been devised. In all such, however, the point of departure has been an assumed size of chamber and a consequent determination of the resulting movement of the water. In the present paper the order is reversed. A program is imposed on the water and a surge chamber is found suitable for the realization of these imposed conditions. Taken in this order, the equations by the use of methods of approximate integration and differentiation admit of direct solution without trial and error adjustment. This method is described and illustrated in operative detail, with appendices giving the necessary mathematical discussion.

The relations between the characteristics of the acceleration curve for the water and the resulting form and dimensions of the chamber are discussed in detail and methods are developed for the rapid derivation of a series of chambers from a single type acceleration curve; also, for the determination of a chamber of such form and size as shall produce a non-oscillatory movement of the water in the chamber. Illustrative cases with graphical representation of the quantities involved are given in Appendix No. 3.

ON THE CONTROL OF SURGES IN WATER CONDUITS

By W. F. Durand, Stanford University P. O., Cal.

Member of the Society

The literature of the problem of the surge chamber as a means of control of surges in water conduits has recently been enriched by two important papers presented before the Society, one by Raymond D. Johnson[1] and another by William F. Uhl,[2] in the latter case the treatment of the surge chamber being incidental to its relation to the general problem of speed regulation.

2 The attention of the writer has been directed recently to the examination of certain cases of surge-chamber design in which funnel or tapering forms rather than cylindrical forms are indicated by the environment and conditions of the problem. This has led to the re-examination of the various methods of treatment available, and to the development of a method by which, without prohibitive labor, the approximations of the various analytical and empirical methods may be avoided and a chamber determined of any desired degree of taper and suited to the development of any desired program as to rate of acceleration and amplitude of surge.

3 In connection with Fig. 1, let us assume the following notations:

v = velocity in general in conduit AB, assumed here of uniform cross-section area
v_1 = initial velocity for period under consideration
v_2 = velocity when movement of water level reaches first maximum
v_3 = velocity for ultimate steady conditions
v^1 = velocity such that v^1A = volume of water demanded by wheels under governor control for constant power during period under consideration

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[1] Trans. Am. Soc. M. E., vol. 30, p. 443.

[2] The Journal Am. Soc. M. E., February 1911, p. 169.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

A = cross-section area of conduit
F = cross-section area of surge chamber at water level
$n = \frac{F}{A}$
L = length of conduit AB
y = distance of water level in surge chamber from initial position for steady motion with velocity v_1
Y = distance of water level in surge chamber from static level
$a = \frac{L}{g}$
b = factor such that bv^2 = sum of friction and velocity heads at B; then
$Y = y + bv_1^2$ for demanded load

and

$Y = 2y + bv_2^2$ for rejected load
H = gross head at wheels
h = total head involved in friction and acceleration
C = coefficient in Chezy formula[1]
r = hydraulic mean radius of conduit

4 In practice h will be of the form

$$h = fv^2 + h_0 + a\frac{dv}{dt}$$

where f = the value of $\frac{L}{C^2r}$ in the Chezy formula, v = the velocity in AB, h_0 = the sensibly constant friction loss for the part of the conduit or penstock lying between the surge chamber and the wheels, computed by the same formula and with a velocity corresponding sensibly to v_3 in AB and $a\frac{dv}{dt}$ = acceleration head. For rejected load $a\frac{dv}{dt}$ becomes negative and is therefore subtractive from the sum of $fv^2 + h_0$.

5 It should be noted that we shall here use the term "surge" not in the sense of the total or maximum movement of water during a period of changing load, but rather as the maximum distance by which the water level passes beyond its final location for steady conditions with the corresponding ultimate velocity.

6 In Appendix No. 1 it is shown that the differential equations for the movement of the water in the conduit and surge chamber are as follows:

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[1] Friction head = $\frac{Lv^2}{C^2r}$

$$\text{Demanded Load}\ldots\ldots \begin{cases} a\dfrac{dv}{dt} = y - b(v^2 - v_1^2) & \ldots\ldots\ldots\ldots [1] \\ n\dfrac{dy}{dt} = (v^1 - v) & \ldots\ldots\ldots\ldots [2] \end{cases}$$

$$\text{Rejected Load}\ldots\ldots \begin{cases} a\dfrac{dv}{dt} = y - b\,(v_1^2 - v^2) & \ldots\ldots\ldots\ldots [3] \\ n\dfrac{dy}{dt} = (v - v^1) & \ldots\ldots\ldots\ldots [4] \end{cases}$$

7 For constant power during the period of change, equal to that under steady conditions with the velocity v_3, we shall also have:

$$v^1\,(H - h) = v_3\,(H - h_3) \quad \ldots\ldots\ldots\ldots [5]$$

or

$$v^1 = v_3\frac{H - h_3}{H - h} \quad \ldots\ldots\ldots\ldots [6]$$

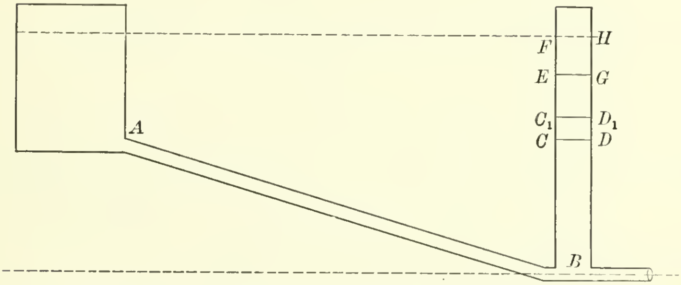

FIG. 1 DIAGRAM SHOWING ARRANGEMENT OF CONDUIT AND SURGE CHAMBER

EG denotes level for steady motion with velocity v_1
C_1D_1 denotes level for steady motion with velocity v
CD denotes actual level with velocity v
$EC = y$
$FC = Y$

8 These equations in effect represent a damped oscillation in which the damping force varies with the square of the velocity. In this form they have not been integrated, nor do they seem susceptible of integration, at least in terms of present known functions.

9 Under these circumstances, several courses are open as follows:

a The omission of the frictional or damping term and of the influence due to governor control. This is equivalent to taking $b = o$ and $v^1 = v_3$. This simplifies the problem to such a degree that it is readily treated by exact mathematical methods. Such results have been developed many times and discussed by various authors. The assumed condition is, however, so far removed from the actual that the results are of small value except as a first step in the approach to the real problem.

b The substitution of a damping force varying as the first power of the velocity instead of as the square. This with suitable assumptions regarding the influence due to governor control makes possible the integration of the equation and renders the treatment similar to that for certain types of electrical oscillations. This substitution lies at the foundation of the masterly analytical treatment of the problem by certain eminent European engineers.[1] At the best, however, this method is approximate and must needs be under control by reference to some more exact method in order to know the order of error involved or to determine values of arbitrary constants.

c The development of approximate and empirical equations upon the various assumptions involving more or less simplification of the original equations, and involving the use of empirical coefficients derived from actual cases by means of method *d*. The paper by Johnson above referred to, with the accompanying discussion, furnishes a large number of such formulae developed either by the original author or by the authors of the discussion, and by means of which most problems within the field of control may be very satisfactorily treated. By the field of control is here meant the field over which are scattered the actual cases worked out by more exact methods and the results of which have been used to check the coefficients and results in general for the various approximate equations.

d The equations may be treated by approximate numerical integration in a step-by-step trial and error process. It will be obvious that by an appropriate procedure the equations may be treated by this general method whether n is constant or variable so long as the proposed form of chamber is specified.

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[1] Prasil, Wasserschloss probleme—Schweizer Bauzeitung—Band 52 Nr 21, 23, 24, 25.

10 In the methods of treatment indicated under *a*, *b* and *c*, it is of course, assumed that n is a constant. The more general assumption that n is a variable, that is, that the chamber may be of conical or vase-like form, would require the expression of n as a function of y. This would result in the general case in a further complication which would render still more difficult or impossible the treatment of the problem on the assumptions made in *a*, *b* and *c*.

11 In the literature of the present subject many illustrations[1] of method *d* for constant n will be found in the annals of the Society as well as in other engineering and scientific works. The writer has done, perhaps, a fair share of the tedious work involved in the application of this method, and it was in a measure as a revolt against this serious expense of time, that the method which forms the subject of the present paper was developed.

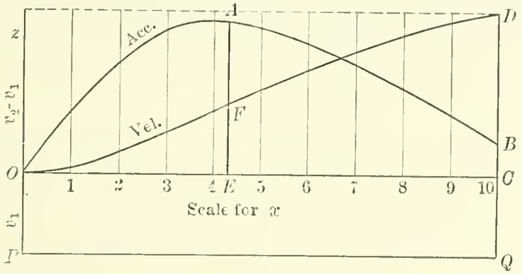

FIG. 2 DIAGRAM SHOWING RELATION OF ACCELERATION AND VELOCITY CURVES ON TIME AXIS

12 In all of the preceding methods whether by analytical approximation or by numerical integration, the method of approach to the problem is as follows: Given a specified or proposed surge chamber, what will happen? Let us reverse the order and state the question thus: Given a program for the water, required a surge chamber to produce it.

13 To develop the possibilities of this viewpoint, let us fix in advance the character of the acceleration of the water in the conduit as indicated by the curve OAB in Fig. 2, in which diagram time is laid off on the x-axis, but without as yet any determination of scale; and acceleration is laid off on the z-axis without as yet any determination of scale.

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[1] The Surge Tank in Water-Power Plants, R. D. Johnson, Trans. Am. Soc. M. E., vol. 30, p. 443.

14 The curve *OAB* is then taken as the proposed history of the acceleration up to the time when the water reaches its highest or lowest level, according as the case is for rejected or demanded load. In order to fix the ideas, we shall for the present assume the case of demanded load and a falling surface of water. Then the acceleration curve *OAB* and the time *OC* both relate to the period from the start to the attainment of a maximum drop of water surface or to a maximum value of y. The plotting of this curve does, therefore, nothing more than to fix in advance the general type or form of the acceleration curve, leaving all questions of actual numerical values for later determination. Methods for the determination of the scale factors and the numerical values will be found in Appendix No. 2. In order not to interrupt the continuity of development of the general method, the question of scales may be waived for the moment and we may assume *OAB* to represent definitely the time history of the acceleration $\frac{dv}{dt}$.

15 By means of a planimeter, or by arithmetical means, or by an integraph, if such an instrument should be available, the first integral curve of *OAB* is readily found as shown by *OD*. This will give the time history of the change in velocity from v_1 to v_2. Lay off v_1 as *OP* and draw *PQ*. Then from *PQ* as an axis the curve *OD* will give the complete time history of the velocity in its growth from $PO = v_1$ to $QD = v_2$.

16 Now, writing equations [1], [2] and [5], we have

$$a\frac{dv}{dt} = y - b(v^2 - v_1^2) \qquad [7]$$

$$n\frac{dy}{dt} = (v^1 - v) \qquad [8]$$

$$v^1 = v_3\frac{H - h_3}{H - h} \qquad [9]$$

In equation [7], it is readily seen that we now know all quantities except y. Hence, by direct substitution, we find y for a series of values of the time, and if desired we may plot the result as a curve of y on time.

17 This curve is indicated in Fig. 3 by *OAB*. Let *CA* denote the level for steady conditions with the final velocity v_3, then $OC = b\,(p_3^2 - v_1^2)$, while *CD* denotes the extent of the surge or drop below *CA*, the final level for steady conditions. We next proceed to differentiate

the curve OAB. This may most easily be done by numerical methods as given in Appendix No. 1. At any given point, or value of the time, this will give the value of $\frac{dy}{dt}$. We may also find v^1 from [9], and thus in [8] we have all quantities known except n, which may be found by the solution of this equation.

18 The time histories of all quantities, $\frac{dv}{dt}$, v, y and n, are now known. We may as desired, plot $a\frac{dv}{dt}$, v and n on y and in particular may reduce n to the diameter of the chamber and plot on y, thus showing for the chamber the form and dimensions required. In case the influence of governor control is omitted, we may put $v^1 = v_2$ in [8] and discard [9]. This will simplify the operations to a considerable degree.

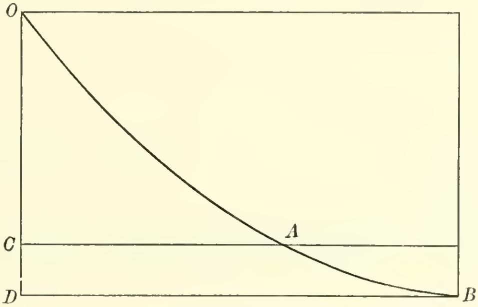

Fig. 3 Diagram showing Movement of Water Level on Time Axis

19 The time required for the complete treatment of a given case by this method might be from two to four hours, depending on the number of points found, the degree of accuracy required, etc. The aid of a slide rule of the Fuller or Thatcher form and giving a fifth place by estimation is assumed.

20 After a given case has been worked through for a single value of the time, a second case with a different value of the time and the same acceleration curve, except for slight modifications near the end, may be worked through with considerable saving of time. In this manner, a series of forms of the chamber may readily be derived from a single base or type curve of acceleration.

21 After the area of the acceleration curve has been found, the areas of the chamber at the top and near the bottom or at the top, near the bottom and at one or two intermediate points may quickly be found, and independently of the detailed determination of the

curve of y as described in Par. 16. In this manner the general character of the chamber may be readily foreseen in advance of the complete and detailed determination of its form. The resulting value of $y_{\max}$ and hence the amount of surge may also be found immediately and in advance of the detailed determination of the y curve or of the form of the chamber. The general characteristics of the acceleration curve may also be readily adjusted to produce a chamber of any desired general character of form and size.

22 In Appendix No. 2 will be found further discussion of these details of the operative program, together with the numerical work for a typical case, the latter indicating in detail the various steps. A study of this form of computation together with the fundamental equations, will better serve to acquaint the reader with the operative details of the method than further descriptive treatment.

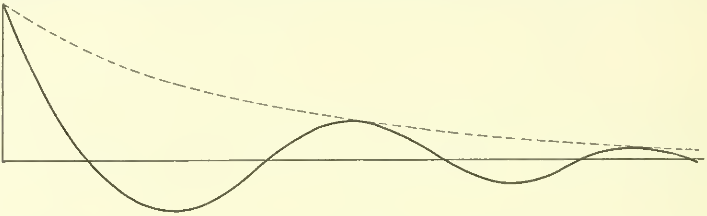

Fig. 4 Diagram illustrating Oscillatory and Non-Oscillatory Movements

NON-OSCILLATORY MOVEMENT

23 One special case merits particular attention. The movement of the water surface has been referred to as that of a damped oscillation. The peculiar characteristic of such a movement lies in the fact that it involves a continuous and indefinite approach to a final level or condition or axis by means of an indefinite series of swings or oscillations of decreasing amplitude and lying on either side of the final level, or axis, and as represented by the full line in Fig. 4.

24 Now the limiting case of such a movement is that of a single swing or indefinite approach to the final level or condition or axis, but without passing beyond, and lying wholly on one side of such a final goal. Such a movement is indicated by the dotted line in Fig. 4. This condition has its direct analogy in certain types of electrical non-oscillatory discharge.

25 Now in the case of a hydraulic conduit with surge chamber, the realization of a non-oscillatory movement of the water in the chamber may well be considered as a most desirable ideal in case the

needed dimensions are practicable. The dimensions and form of such a chamber are readily determined by the choice of an appropriate form of acceleration curve combined with a suitable time allowance.

26 It is clear when the water reaches its final level that in all cases we must have simultaneously the velocity $\frac{dy}{dt}$ and the acceleration $\frac{dv}{dt}$ equal to zero. This results from the form of the y curve which is here coincident with the axis. If this final condition is to be realized by a non-oscillatory movement, then the one swing of the water surface which represents the passage from the initial level to its maximum drop and the simultaneous change of velocity from v_1 to v_3 must be conditioned by a suitable form of acceleration curve. Obviously, this will be a curve of the form indicated in Fig. 5, where $OABC$ indefinitely approaches x and the value of the acceleration indefinitely decreases as time increases. Theoretically, we should realize the final conditions only after an infinite time.

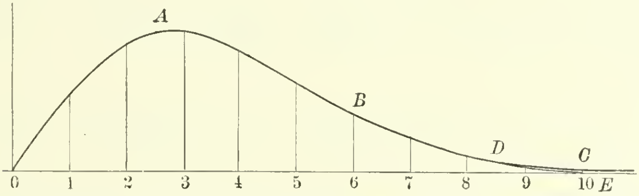

FIG. 5 DIAGRAM SHOWING TYPE OF ACCELERATION CURVE FOR NON-OSCILLATORY MOVEMENT

27 Practically two courses are open:

a A form of curve $OABC$ where the terminal point C lies near but not quite on the x-axis is assumed. In other words, a finite part of the indefinitely extended curve is used implying for the conditions when y reaches its first maximum value, a slight residual acceleration, and hence a slight surge or movement of the water surface beyond its level for steady conditions. By taking C near the axis this surge may be reduced to an entirely insignificant value, and the resulting movement thus made sensibly non-oscillatory. In such a case the mode of procedure is the same as for the general case.

b A form of curve $OABDE$ in which the curve is brought down tangent to x within a finite distance is assumed.

In the general case with an acceleration curve of the form shown in Fig. 2 or *OABC*, Fig. 5, it is shown in Appendix No. 2 that there is but one particular value of the time which will fit the various conditions imposed, and the time thus determined is therefore that required for the first swing to a maximum value of y.

28 In case, however, the curve is assumed of the form *OABDE*, it is shown that the time is not determined by the conditions thus imposed, and in consequence we are free to choose any value of the time whatever, as long as it does not fall below a certain limiting minimum. For each value of the time which may thus be taken, a corresponding chamber will result suitable for the realization of the proposed program of acceleration, non-oscillatory movement of the water, etc., and all within the assumed time. In this manner a series of chambers may be developed from one assumed base curve of acceleration, the required work for all cases after the first being comparatively small. An illustrative case with further discussion of operative details will be found in Appendix No. 3.

RELATIONS BETWEEN FORM OF ACCELERATION CURVE AND CHARACTERISTICS OF CHAMBER

29 Regarding the selection of a form of acceleration curve which will correspond to any proposed general form of chamber a very little experience with the treatment of such problems serves to show the general type of acceleration curve produced by chambers of cylindrical or tapering form. The value of the acceleration starting at zero mounts rapidly to a maximum during the early part of the total period, and then falls off more gradually to its value for $v = v_2$, either zero or some relatively small value, as shown in Figs. 2 and 5, according as it is intended to have the movement non-oscillatory or to permit a small surge movement. It may also be readily seen in what manner the form of the curve should be modified in order to produce any desired change in the amount of surge, the time required or the general form of the resulting chamber.

30 A further important question in the case of non-oscillatory movement refers to the relation between the change in the time allowed and the resulting change in the form of the chamber, the form of the acceleration curve remaining the same.

31 In Appendix No. 2 will be found a detailed discussion of these points including the development of such relations as will

provide for the ready adjustment of a curve of acceleration suited to develop any general form of chamber as desired, and to secure any specified program as regards the movement of the water, permissible extent of surge, time required, etc.

THE RELATION BETWEEN DEMANDED AND REJECTED LOAD

32 The general discussion of this method of treatment has assumed the condition of demanded load where any differences were involved. It is evident that precisely the same methods may be applied to the case of rejected load. The latter investigation may be of special importance in connection with the permissible height of surge in case a moderate surge may be permitted. It will scarcely be necessary to discuss this case in detail, or to develop the special forms which the various equations will take.

33 An examination of the various equations for this case will show that for a given program of acceleration, etc., a chamber of different form and in general of smaller capacity will be required than for the case of demanded load. Or otherwise with a given chamber, the program of water movement, extent of surge, etc., will be somewhat less than for the case of demanded load. It follows therefore, in the case of substantially non-oscillatory movement in particular, that a chamber developed to secure this character of movement for demanded load, will in a still higher degree secure the same result for rejected load.

34 It is, of course, evident that a chamber developed for the case of demanded load will not, in the case of rejected load, give the same program of acceleration, etc. The acceleration at the start with tapering chamber will be more abrupt and the acceleration curve will be steeper, the range of values, however, running less than for the case of demanded load.

35 If for a chamber developed for the case of demanded load it is desired to determine the detailed results in the case of rejected load, there seems to be no more direct method than the regular solution of the equations for this case by means of approximate integration and trial and error adjustment.

SOURCE AND CHARACTER OF ERRORS

36 The degree of accuracy which may be expected in the solution of problems of this character, together with the sources of uncertainty

or error merit brief notice. Errors in the final results may arise from four chief causes:

a The failure of the general equations properly to include all the factors or conditions of the problem.

b The adoption of approximate methods of treatment involving the omission of various factors or the simplification of their relations to the problems, all for the purpose of bringing the equations or the resulting conditions within the range of ready mathematical treatment.

c Uncertainty regarding the values to be ascribed to various empirical constants.

d The inaccuracies of numerical computation.

37 In the case of the present problem, errors of class *a* may arise from the failure of the governor to work perfectly, and from a slight change in the efficiency of the wheels with change in effective head and hence in spouting velocity. These conditions will affect the virtual velocity v^1 and hence in any given case the actual values of v^1 may not be equal exactly to those given by equation [6].

38 In no actual case furthermore, does the load remain perfectly constant. In many cases it may remain sensibly constant, while in some the governor will be continually chasing the conditions developed by the load, but never quite overtaking or controlling them. Assuming, however, for the sake of definiteness of condition that the load is uniform and that the velocity v^1 is properly given by [6], it appears that all remaining conditions with the exceptions noted in Par. 39 are properly represented in the general equations.

39 The influence of acoustic waves and their time element are not included in the fundamental equations as developed. There is good reason for such omission in the fact that the time element introduced by the acoustic wave is small compared with the time involved in the rise and fall of water in a surge chamber, and no sensible error will result from such omission in dealing with surge chamber problems. On the other hand, as is well known, the time element introduced by the acoustic wave must be considered in the general problem of governor control.

40 Errors of class *b* are necessarily present in all analytical treatments of the present problem. The present method eliminates errors of this class.

41 Errors of class *c* in the proposed method of treatment depend solely on the value of the coefficient for loss of head due to friction.

It will be noted that the coefficient *b* in the general equations is the only one which involves empirical constants of this character.

42 Errors of class *d* are wholly under control. They may be reduced to any desired limit by a suitable adjustment of the program of numerical computation.

43 It follows in the proposed method of treatment, assuming the conditions of the problem to be properly represented by the general equations, that the only source of unavoidable error lies in the coefficient for friction loss. The results therefore, when derived by the aid of adequate methods of numerical computation, must represent the consequences of the assumed conditions with the same degree of accuracy as that with which we may compute the final effective head, the horsepower with an assumed wheel efficiency, or any other simple result for which the friction head is a determining factor.

APPENDIX NO. 1

GENERAL EQUATIONS OF MOTION FOR THE CASE OF A CONDUIT MADE UP OF SECTIONS OF DIFFERENT SIZES AND HENCE CONTAINING COLUMNS OF WATER MOVING AT DIFFERENT VELOCITIES.

44 The general equations for the motion of the water in a pipe line of uniform cross-section under the influence of a surge chamber have been so frequently derived and are so well known in the literature of the subject that their derivation as a special case may be omitted.

45 It not infrequently occurs, however, that the conduit as a whole is made up of sections of different sizes and lengths and hence at any instant contains columns of water of varying weights and moving with different velocities. The usual equations of motion which are based on an assumed uniform section, and hence uniformity of velocity throughout the conduit, cannot be used for this case. It therefore becomes of practical importance to determine the more general equations for this case.

46 Referring to Fig. 6 we shall use the following notation:

A, A_b, A_c to denote areas of sections a, b, c

u, v_b, v_c to denote velocities in sections a, b, c

It will be noted that the conditions in section a are to be taken as standard, and hence the area and velocity for this section are denoted by A and u without a special subscript.

u_1 = initial velocity in section a

u_2 = velocity in section a when movement of water level reaches first maximum

u_3 = velocity in section a for ultimate steady conditions

m = ratio between velocity in any section and that in section a, that is

$$v_b = m_b u$$
$$v_c = m_c u, \text{ etc.}$$

Hence, we shall have

$$A_b = \frac{A}{m_b}$$

$$A_c = \frac{A}{m_c}$$

V = volume of 1 lb. of water

σ = density

C = coefficient in Chezy formula

r = hydraulic mean radius

u^1 = velocity in section a which would carry just the volume of water demanded by the wheels when under governor control during the period under consideration

h = total lost head between intake of conduit and wheels

Then h = friction head + acceleration head

H = gross head at W

F = area of surge chamber at water level

$n = \dfrac{F}{A}$

y = movement of water level in surge chamber from position for steady motion with velocity u_1

Y = movement of water level in surge chamber from static level

47 To fix the ideas we shall assume the condition of demanded load and hence of increasing velocity, and write the general equation of work-energy for 1 lb. of water entering the conduit at B and passing out at E.[1] We shall take the datum level at E since only the parts of the system lying above this datum are directly involved. At the point B we shall have the following items of work-energy inflow:

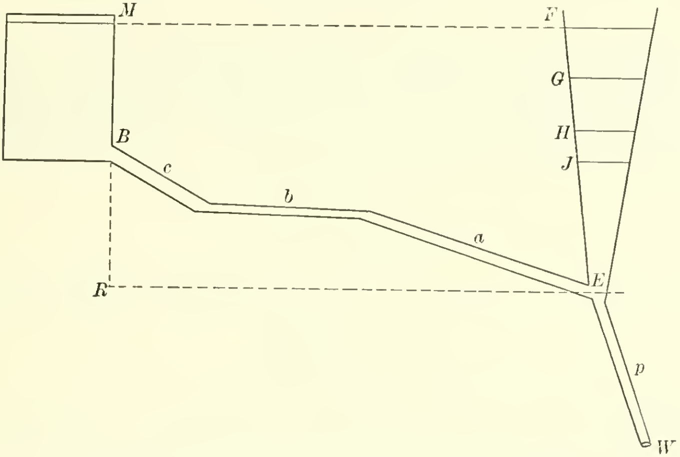

Fig. 6 Diagram showing Conduit Line of Mixed Sizes with Surge Chamber

F denotes level for static conditions
G denotes level for steady conditions with velocity u_1 in section a
H denotes level for steady conditions with velocity u in section a
J denotes level for actual conditions with velocity v in section a

$$\frac{v_c^2}{2g} = \text{kinetic energy}$$

Head BR = potential energy

$$P_B V = \frac{P_B}{\sigma} = \text{work done on entering pound of water}$$

These constitute the total work-energy input at B.

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[1] The influence due to entrance head at the intake of the conduit is omitted as usually too small to be of significance.

48 Corresponding and equal to this total input, we have a threefold subdivision as follows:

- *a* A part is represented by the work required to overcome frictional resistance in the conduit.
- *b* A part is represented by increase in the kinetic energy of the water in the conduit which is undergoing continuous acceleration and hence is increasing in energy content.
- *c* The remainder is represented by the work-energy output at the point *E*.

Taking first the work required to overcome the skin friction in the conduit, we have for any section of length L, hydraulic radius r, coefficient C and velocity v.

$$\text{loss of head}^1 = \frac{v^2 L}{C^2 r}$$

49 This is commonly called loss of head. It is readily seen that in effect it is the measure of the work required to overcome the frictional resistance throughout a conduit of length L per lb. of water entering or leaving, or in general per lb. of water flowing past any given section. In the present case all quantities are taken per lb. of water so that for any section in general, we shall have for the work expended in friction,

$$\text{work} = \frac{v^2 L}{C^2 r}$$

For the entire conduit made up of sections of mixed sizes, we shall have

$$\text{work} = \Sigma \left(\frac{v^2 L}{C^2 r} \right)$$

where Σ denotes simply the summation of the series of partial amounts for each individual section of the total conduit. But, in general $v = mu$ and hence

$$\text{work} = \Sigma \left(\frac{v^2 L}{C^2 r} \right) = u^2 \Sigma \left(\frac{m^2}{C^2 r} \right)$$

50 We have next for the kinetic energy in any section of the conduit,

$$\text{energy} = K = \frac{\sigma A L v^2}{2g}$$

Then in time dt this is subject to change (in the present case increase) by the amount

$$dK = \frac{\sigma A L v}{g} \times \frac{dv}{dt} dt$$

Now for 1 lb. to enter at B or to pass E or in general to pass any given point, the time is

$$dt = \frac{1}{\sigma A v}$$

---

[1] This follows directly from the Chezy formula.

Substituting this value of dt in the above value of dK we have

$$dK = \frac{Ldv}{gd_t}$$

Hence the total amount of energy absorbed in the acceleration of the contents of the entire conduit will be

$$\Sigma\, dK = \Sigma \left(\frac{Ldv}{gdt}\right)$$

But since in general $v = mu$, we have

$$\frac{dv}{dt} = m\frac{du}{dt}$$

and

$$\Sigma dK = \Sigma \left(\frac{Ldv}{gdt}\right) = \frac{du}{dt}\Sigma\left(\frac{mL}{g}\right)$$

51 Finally, at the point of exit E, we have the following items of work-energy output

$$\frac{u^2}{2g} = \text{kinetic energy}$$

$$P_E V = \frac{P_E}{\sigma} = \text{work done on outgoing lb. of water}$$

Hence, collecting and equating we have

$$\frac{v^2}{2g} + BR + \frac{P_B}{\sigma} = u^2\,\Sigma\left(\frac{m^2L}{C^2r}\right) + \Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} + \frac{u^2}{2g} + \frac{P_E}{\sigma} \;\ldots\ldots\; [10]$$

But

$$\Sigma\,\frac{v^2L}{C^2r} = u^2\,\Sigma\left(\frac{m^2L}{C^2r}\right) = \text{total friction head}$$

Hence

$$u^2\left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right] = FH$$

Also

$$\frac{P_E}{\sigma} = JE$$

Hence [10] is eqivalent to

$$MR = FH + JE + \Sigma\left(\frac{mL}{g}\right)\frac{du}{dt}$$

or

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = MR - (FH + JE) = HJ \;\ldots\ldots\ldots\ldots\; [11]$$

But

$$HJ = y - GH$$

and

$$GH = FH - FG = \begin{cases} \text{difference of total friction and velocity} \\ \text{heads for velocities } u_1 \text{ and } u \end{cases}$$

Hence, we have

$$GH = \left[\Sigma \left(\frac{m^2L}{C^2r} \right) + \frac{1}{2g} \right] (u^2 - u_1^2)$$

and [11] becomes

$$\Sigma \left(\frac{mL}{g} \right) \frac{du}{dt} = y - \left[\Sigma \left(\frac{m^2L}{C^2r} \right) + \frac{1}{2g} \right] (u^2 - u_1^2) \ldots\ldots\ldots\ldots [12]$$

It thus appears that in such a conduit with mixed sizes the virtual or equivalent length in the term involving acceleration is $\Sigma\ mL$ while in the term involving friction the virtual term $\frac{L}{C^2r}$ is $\Sigma \left(\frac{m^2L}{C_2r} \right)$

52 In accordance with the preceding notation, the amount of water required at any given instant during the period of change is u^1A. The amount which is coming through section a of the conduit is uA. Hence, assuming $u^1 > u$ the remainder must come from the surge chamber. In general, we shall have

$$u^1A = uA + F\frac{dy}{dt}$$

or

$$\frac{Fdy}{Adt} = n\frac{dy}{dt} = (u^1 - u) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [13]$$

Also h = friction head plus acceleration head or

$$h = \Sigma \left(\frac{m^2L}{C^2\,r} \right) u^2 + \Sigma \left(\frac{mL}{g} \right) \frac{du}{dt} + h_0 \ldots\ldots\ldots\ldots\ldots [13]_1$$

where h_0 represents the sensibly constant friction loss in the section of the conduit between the surge chamber and the wheels, and which may be based on a sensibly uniform velocity corresponding to u_3 in section a. Frequently this term h_0 will vanish. Then for constant power during the period under consideration we shall have

$$u^1A\ (H - h) = u_3A\ (H - h_3)$$

Hence

$$u^1 = u_3 \frac{(H - h_3)}{(H - h)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [14]$$

53 It is evident that the total friction head as a part of h and h_3 must be found by summing the friction heads for the various parts of the entire line including the penstock p. It should also be noted that the pipe p is carrying the total volume of water while the conduit abc is carrying only a part. The velocities in these various sections must therefore be taken accordingly. No sensible error will be involved if the velocity in p is taken as uniform and of such value as to correspond to u_3 in section a. Rewriting [12], [13] and [14] to bring them together, we have

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = y - \left[\Sigma\left(\frac{m^2L}{C^2r}\right) + \frac{1}{2g}\right](u^2 - u_1^2) \quad\ldots\ldots\ldots\ldots [15]$$

$$n\frac{dy}{dt} = \left(u^1 - u\right) \quad\ldots\ldots\ldots\ldots [16]$$

$$u^1 = u_3\frac{(H - h_3)}{(H - h)} \quad\ldots\ldots\ldots\ldots [17]$$

54 If the conduit is of uniform section then m becomes 1 in all cases and putting L the length of the conduit for ΣmL and Σm^2L and writing now v instead of u, we have

$$\frac{L}{g}\frac{dv}{dt} = y - \left(\frac{L}{C^2r} + \frac{1}{2g}\right)\left(v^2 - v_1^2\right) \ldots\ldots\ldots\ldots [18]$$

55 Equations [16] and [17] remain the same in form for this case as for the more general. If we neglect the influence due to governor control and assume that the flow of water is uniform in volume and equal to u_3A then u^1 becomes u_3 and equation [17] may be discarded.

56 A comparison of equations [15] and [18] shows, as might be expected, that the equation for a conduit with mixed sizes is similar in form to that with uniform size, but with different coefficients for the terms involving acceleration and friction. It also appears that by using the velocity and acceleration in some one section as standard, the case with mixed sizes may be thus reduced to an equivalent or virtual case with uniform size.

57 The preceding various equations in the form given apply to the case of demanded load. For the case of rejected load the modifications are readily made. The resulting equations are

$$\Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} = y - \left[\Sigma\left(\frac{m^2 L}{C^2 r}\right) + \frac{1}{2\,g}\right](u_1^2 - u^2) \ldots\ldots\ldots\ldots [19]$$

$$n\frac{dy}{dt} = (u - u^1) \ldots\ldots\ldots\ldots [20]$$

$$u^1 = u_3\frac{(H - h_3)}{(H - h)} \ldots\ldots\ldots\ldots [21]$$

$$h = \Sigma\left(\frac{m^2 L}{C^2 r}\right)u^2 - \Sigma\left(\frac{mL}{g}\right)\frac{du}{dt} + h_0 \ldots\ldots\ldots\ldots [21]_1$$

APPENDIX NO. 2

THE DERIVATION OF SCALE RATIOS AND NUMERICAL RELATIONS FOR ANY GIVEN ACCELERATION CURVE

58 Repeating Fig. 2, the following notation will be used:

x to denote the abscissa
z to denote the ordinate
α to denote the scale ratio for z
β to denote the scale ratio for x
R to denote the area of acceleration curve $OABC$

Then for the acceleration corresponding to any point on the curve, we have

$$\frac{dv}{dt} = \alpha z$$

For the time, we have

$$T = \beta x$$

or otherwise β is the value of the time interval or unit adopted for x.

59 From equations [1], [2] and [6] we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2) \qquad [22]$$

$$\frac{dy}{dt} = \frac{v^1 - v}{n} \qquad [23]$$

$$v^1 = v_3\frac{H - h_3}{H - h} \qquad [24]$$

Differentiating [22], we have

$$\frac{dy}{dt} = a\frac{d^2v}{dt^2} + 2bv\frac{dv}{dt} \qquad [25]$$

Whence from [23] and [25]

$$\frac{v^1 - v}{n} = a\frac{d^2v}{dt^2} + 2bv\frac{dv}{dt} \qquad [26]$$

60 At the end of the period under consideration both v^1 and v become v_2. Hence $v^1 - v = 0$ and we must have as a necessary condition at the end of such period

$$a\frac{d^2v}{dt^2} = -2bv_2\frac{dv}{dt} \qquad [27]$$

But referring to the assumed curve of acceleration, we have

and

$$\left.\begin{aligned} \frac{dv}{dt} &= \alpha z \\ \frac{d^2v}{dt^2} &= \alpha\frac{dz}{dt} = \frac{\alpha}{\beta}\frac{dz}{dx} \end{aligned}\right\} \quad \text{[28]}$$

Hence, substituting these values in [27], we have

$$\frac{a\alpha}{\beta}\frac{dz}{dx} = -2bv_2\alpha z$$

Whence

$$\frac{\frac{dz}{dx}}{z} = -\frac{2bv_2\beta}{a}$$

Putting $\frac{dz}{dx} = m$ and solving for β we have

$$\beta = \frac{-am}{2bv_2z} \quad \text{[29]}$$

61 It thus appears that the general equations involve a relation which takes such form where y becomes a maximum at the end of the period (and hence at the terminal end of the acceleration curve), as to provide for the determination of the time scale β and hence of the time T which will be required on the program resulting from the acceleration curve assumed. In other words, the curve as assumed, in conjunction with the constants a, b and the final velocity v_2 will admit of but one value of the time, and hence one value of the time scale β as determined by [29].

62 Again from the relations involved we have

$$\alpha\beta R = \text{total change in velocity} = (v_2 - v_1)$$

whence

$$\alpha\beta = \frac{v_2 - v_1}{R} \quad \text{[30]}$$

and

$$\alpha = \frac{v_2 - v_1}{R\beta} \quad \text{[31]}$$

It remains to determine v_2. The actual relations of v_2 and h_2 are, however, implicit, and hence a value of v_2 must be found by trial which will result in satisfying equations [29] and [30] above and also the following:

$$h_2 = fv_2^2 + h_0 + a\frac{dv}{dt}$$

$$\frac{dv}{dt} = \alpha z$$

$$v_2 = \frac{v_3(H - h_3)}{H - h_2}$$

For demanded load, v_2 will slightly exceed v_3. Often the difference will be too small to be of significance. In any case, the value is readily found by trial substitution in the above equations.

63 Likewise in general, change of velocity for any period of time equals area of corresponding part of acceleration curve multiplied by $\alpha\beta$ or

$$\Delta v = \frac{v_2 - v_1}{R} \int \frac{dz}{dx} dx \qquad [32]$$

That is, at any point as E the change of velocity will equal $\alpha\beta \times$ area OAE. Let OFD be the integral curve of OAB, that is, a curve such that any ordinate EF is proportional to the area OAE. Then ordinates similar to EF represent areas similar to OA, and it follows that in order to transform the ordinates of OFD into velocity changes we have only to multiply by the value of $\alpha\beta$ as found in [29]. Likewise, if we multiply the ordinates of the acceleration curve OAB by α we shall have the corresponding value of the actual acceleration $\frac{dv}{dt}$. From equation [22] we are now able to derive the values of y and to plot them if desired.

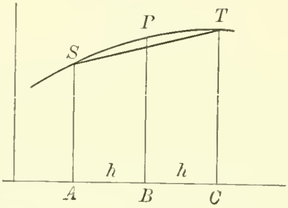

FIG. 7 DIAGRAM SHOWING METHOD OF FINDING TANGENT LINE TO A GIVEN CURVE

64 To derive the values of $\frac{dy}{dt}$ we proceed as follows: In Fig. 7 let SPT be an arc of any curve for which AS, BP and CT are three consecutive ordinates separated by equal spaces K. Then it is well known that for a second-degree parabola[1] passing through S, P and T the tangent at the point P is parallel to the chord ST. Now if the points S and T are not too far removed from P, a second-degree parabola will lie very close to the actual curve, and the tangent to the parabola at P will lie very close to the tangent to the given curve at the same point. That is, under the circumstances specified, it is clear that the two curves at P will have sensibly the same direction and hence the tangent found in this manner will give a good approximation to the true value. Hence, if we denote the ordinates by subscripts 1, 2, 3, we shall have

$$\left(\frac{dy}{dt}\right)_2 = \frac{y_3 - y_1}{2h} \qquad [33]$$

---

[1] Mathematical Treatment of Continuous Functions by Approximate Methods, Sibley Journal of Engineering, January 1894.

This gives a numerical method for finding $\frac{dy}{dt}$ for the curve of y on time at all except the first and last points.

65 For points such as S and T (Fig. 7) it has been shown[1] that the values of $\frac{dy}{dt}$ for the second-degree parabola are as follows:

$$\left(\frac{dy}{dt}\right)_1 = \frac{4y_2 - 3y_1 - y_3}{2h} \quad \text{[34]}$$

$$\left(\frac{dy}{dt}\right)_3 = \frac{y_1 + 3y_3 - 4y_2}{2h} \quad \text{[35]}$$

66 Instead of the preceding method of finding values of $\frac{dy}{dt}$ involving the numerical differentiation of the y curve, we may utilize [25] giving:

$$\frac{dy}{dt} = \left(\frac{a\alpha}{\beta}\right)\frac{dz}{dx} + 2\alpha bvz$$

or

$$\frac{dy}{dt} = \alpha\left(\frac{adz}{\beta dx} + 2bvz\right) \quad \text{[36]}$$

The determination of $\frac{dy}{dt}$ in this manner involves the differentiation of the z or acceleration curve instead of the y curve, and may in certain cases be the more useful mode of procedure. In particular, it permits of finding the value of n for any point on the z curve in advance of the work required to determine the values of y.

67 This method permits therefore, in particular, the determination, independently of y, of the size of the chamber at the top and near the bottom and at one of two intermediate points as desired, thus indicating the general size and character of the chamber which a given acceleration curve will produce. To this end from [23] we write

$$n = \frac{v^1 - v}{\alpha\left(\frac{a}{\beta}\frac{dy}{dx} + 2bvz\right)} = \left(\frac{R\beta}{v_2 - v_1}\right)\frac{v^1 - v}{\left(\frac{a}{\beta}\frac{dz}{dx} + 2bvz\right)} \quad \text{[37]}$$

68 At the initial instant when time = 0, we have

$$v^1 = v_2\frac{H - h_2}{H - h_1}$$

$$v = v_1$$
$$z = 0$$

---

[1] Mathematical Treatment of Continuous Functions by Approximate Methods, Sibley Journal of Engineering, January 1894.

Hence at the point for $T = 0$ we have

$$n_0 = \frac{v^1 - v_1}{\frac{a\alpha}{\beta}\,\frac{dy}{dx}} = \left(\frac{R\beta^2}{v_2 - v_1}\right)\frac{v^1 - {}_1v}{a\frac{dz}{dx}} \quad\ldots\ldots\ldots\ldots\ldots\ldots [38]$$

The value of $\frac{dz}{dx}$ is to be found as in [34] and then by substitution in [38] the value of n for the point where $y = 0$ is immediately found. A numerical example of these computations will be found in Appendix No. 3

69 If the influence of governor control is neglected, $v^1 = v_3$ continuously and the equations become somewhat simplified as follows: For the value of n at any given point we have from [37]

$$n = \frac{v_3 - v}{\alpha\left(\frac{a}{\beta}\frac{dz}{dx} + 2bvz\right)} = \left(\frac{R\beta}{v_3 - v_1}\right)\frac{v_3 - v}{\frac{a}{\beta}\frac{dz}{dx} + 2bvz} \quad\ldots\ldots\ldots\ldots [39]$$

For the value of n at the beginning of the period when $z = 0$ and $v = v_1$ we have

$$n_0 = \frac{R\beta^2}{a\frac{dz}{dx}} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [40]$$

In equations such as [36], [37], [39] the algebraic sign of $\frac{dz}{dx}$ must be carefully noted.

70 It is seen that at the end of the period both $(v^1 - v)$ and $\frac{dy}{dt}$ become zero together, so that the value for this point becomes indeterminate. By the usual mathematical methods, the expression for n at this point may be evaluated and the resulting value of n found. In general, however, this will be quite unnecessary since the methods previously given provide for the determination of the size for any point as near the end as may be desired. Thus the determination of the size for the point where $x = 9$ on a scale of 10 will in general give a value sufficiently near for any possible practical purpose.

MAXIMUM VALUE OF y

Amount of Surge

71 The maximum value of y will be, of course, the value for the close of the period and when $v^1 = v = v_2$. Substitution in [22] gives

$$y = a\left(\frac{dv}{dt}\right) + b\,(v_2^2 - v_1^2)$$

72 The movement for ultimate steady conditions is $b\ (v_3^2 - v_1^2)$. The difference will be the surge. Hence we have

$$\text{Surge} = a\frac{dv}{dt} + b\ (v_2^2 - v_3^2)\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots [41]$$

or again substituting for $\frac{dv}{dt}$ we have

$$\text{Surge} = a\alpha z + b(v_2^2 - v_3^2)\ldots\ldots\ldots\ldots\ldots\ldots\ldots [42]$$

The value of z used in [42] must, of course, be that for the close of the period or at the terminal end of the acceleration curve. The amount of surge may therefore be computed from [41] or [42], or inversely the characteristics of the acceleration curve may be adjusted in such manner as to secure a surge of any specified limiting value.

DETERMINATION OF SCALE RATIOS AND NUMERICAL RELATIONS FOR THE CASE OF NON-OSCILLATORY MOVEMENT

73 If the curve of acceleration for non-oscillatory movement is taken as *OABC* (Fig. 5), then the program of operation is exactly the same as that for any curve in general, and as already described. It should be especially noted, however, that in order to insure the conditions for a vanishing value of the surge, the relation between the values of z_{10} and $\left(\frac{dz}{dx}\right)_{10}$ must be adjusted so as to give a large value of β. This is apparent from [41] or [42]. By appropriate adjustment, therefore, the conditions may be determined so as to produce a surge of 0.5 ft., 0.1 ft. or any other value which may be considered negligible.

74 In case, however, the curve of acceleration is taken as *OABDE*, then at the point of coincidence with the axis of x we have $z = 0$ and $\frac{dz}{dx} = 0$ or otherwise $\frac{1}{a\alpha}\frac{dv}{dt} = 0$ and $\frac{\beta}{a\alpha}\frac{d^2v}{dt^2} = 0$ [28]. Hence, referring to [25], it appears that $\frac{dy}{dt}$ at this point will become zero independent of the values of β and α or in other words, for all values of β and α. It results that we are free in this case to choose β at will. The outline of the procedure is therefore as follows.

75 The area is found as in the previous case. As before

$$\alpha\beta = \frac{v_3 - v_1}{R}\ .$$

Assuming β at will, gives

$$\alpha = \frac{v_3 - v_1}{R\beta}$$

We then proceed in exactly the same manner as before with the determination of the various quantities, resulting in the ultimate determination of the values of

n and of the size and form of the chamber. The value of $y_{\max}$ in this case is always

$$y_{\max} = b\ (v_3^2 - v_1^2)$$

and equals the fall of water to the level for steady conditions for velocity = v_3. The value of the surge is of course zero by condition. The value of n for $T = 0$ is given by [38] as in the more general case. The value of n for the end of the period is indefinite as in the general case. This, however, is a matter of no significance since the dimensions and form of the chamber are sufficiently determined otherwise.

76 For varying values of β it is evident that since the area of the acceleration curve R remains the same, the value of $\alpha\beta$ will remain unchanged, and hence the entire history of the velocity in its change from v_1 to v_3. Also it is evident that α will vary inversely as β. Hence in the value of y, as given in [22], the term

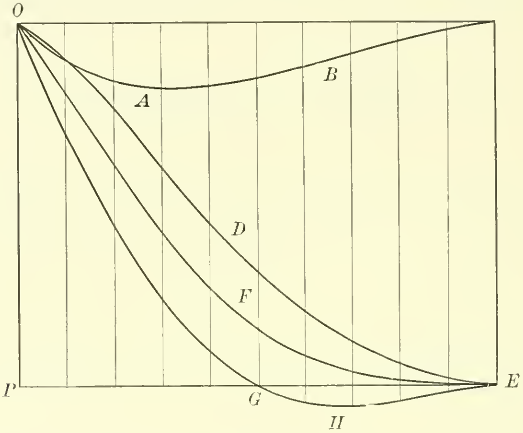

FIG. 8 DIAGRAM ILLUSTRATING METHOD OF FINDING MINIMUM CHAMBER FOR NON-OSCILLATORY MOVEMENT

$a\dfrac{dv}{dt}$ or $a\alpha z$ is the only one undergoing change, and this varies directly as α or inversely as β. Hence for example if β be doubled the values of $a\dfrac{dv}{dt}$ will be halved and the new values may be therefore immediately written from the old. The values of v^1 also remain the same and hence of $v^1 - v$. Hence for a determination of the form of chamber corresponding to a new value of β a part only of the entire program of computation is required, and a series of chambers corresponding to a series of values of β may therefore be quickly derived, once the results for a single case are in hand. At the initial level the area of the chamber will vary as β^2 as in the more general case and as shown by [38].

77 The value for n for an intermediate point is also readily found by the use of [37]. In this expression β is the only term which changes its value and hence for a given intermediate value of v we may find the value of $\dfrac{dz}{dx}$ once for all and then find a series of values of the ratio n. By the use of these direct methods values of n for the initial level and for two other points, one near the middle

and one near the end of the period, may be quickly found for a wide range of values of β. The values of y for such intermediate points are then found from [22] and such values of y and n together with those for the initial level will serve to determine the character of the chambers in general terms.

DETERMINATION OF MINIMUM CHAMBER FOR NON-OSCILLATORY MOVEMENT OF THE WATER

78 While it is true that with a form of acceleration curve such as $OABDE$ the equations may be fulfilled for any value of β or any value of the time allowed, yet the case will fail physically if the time is too short. The conditions determining such limit may be investigated as follows: Rewriting equation [22] we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2)$$

or

$$y = a\alpha z + b\,(v^2 - v_1^2)$$

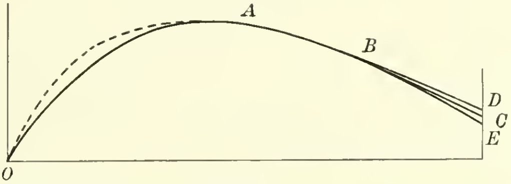

FIG. 9 DIAGRAM ILLUSTRATING RELATION BETWEEN FORM OF CHAMBER AND CHARACTERISTICS OF ACCELERATION CURVE

79 Now plotting separately each of the two terms of the value of y and taking y positive downward, it is seen (Fig. 8) that they are of the forms indicated by $OABC$ for $a\alpha z$ and ODE for $b\,(v^2 - v_1^2)$. In each case the curves have a horizontal tangent at the end of the period, and hence their sum, the curve of y will have a horizontal tangent at the same point, as is required for a maximum or minimum value.

80 Now change of β results in leaving the curve ODE the same, but in changing the scale of $OABC$. Hence with a large value of β and therefore a small value of α and a correspondingly small value of the ordinates of $a\alpha z = a\frac{dv}{dt}$ we shall have a curve of y somewhat as indicated by the line OFE in which, as shown, the water level sinks somewhat rapidly at first and then more and more slowly until it finally settles to E, reaching at this point its maximum value. Suppose, however, the value of β reduced to half its value for this case. Then the ordinates of $OABC$ will be multiplied by two and adding such increased values to ODE, we shall have a result somewhat as in $OGHE$, where as seen, the curve cuts the level PE at G, drops below to a maximum at H and again rises through a point of inflexion to a minimum at E. But

$$OP = b\,(v_3^2 - v_1^2)$$

Hence at the point G we have

$$y = a\frac{dv}{dt} + b\,(v^2 - v_1^2) \;= b\,(v_2^2 - v_1^2)$$

and since $\frac{dv}{dt} = \alpha z$, we find

$$a\alpha z = b\,(v_3^2 - v^2)$$

Substituting from [31] for α and solving for β

$$\beta = \frac{az\ (v_3 - v_1)}{bR\ (v_3^2 - v^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [43]$$

81 Now if we take the values of z and v corresponding to a point very near the end of the curve, say where $x = 9$ on a scale of 10, we shall find the value of β which would cause the y curve to dip across the line PE at this point. Some such value may be taken as the minimum value of β consistent with a substantial fulfilment of the condition of no surge.

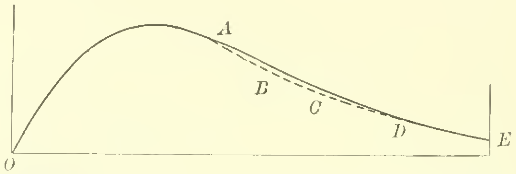

FIG. 10 DIAGRAM ILLUSTRATING RELATION BETWEEN FORM OF CHAMBER AND CHARACTERISTICS OF ACCELERATION CURVE

82 The crossing of the y curve below PE and its later return upward while the velocity is still increasing toward its value v_3 represents an impossible set of physical conditions and the method of computation if carried forward would give an impossible form of chamber. Hence if we employ with the given acceleration curve a limiting value of β found as suggested in Par. 79, it will produce down to the level PE a form of chamber consistent with the physical conditions and which will drop the water level to PE at a time equal to 9β, for example. If the chamber is then continued down as conditions may require and of substantially the same area, it will mean simply a chamber in which the specified conditions of the acceleration curve at the end of the period would be imperfectly fulfilled, and in which there might result an infinitesimal surge. Such chamber would, however, practically fulfil all requirements for determining a movement of the water substantially non-oscillatory, and might be taken as the smallest with which such conditions could be secured, at least on the basis of the assumed acceleration curve.

RELATION BETWEEN FORM OF ACCELERATION AND FORM AND DIMENSION OF CHAMBER

83 Suppose the assumed acceleration curve to be $OABC$. Let the value of β be determined from [29]. Consider the result of slight modification at the end as indicated at BD or BE. For BD the value of z_{10} is increased and

that of m, the tangent of the slope, is decreased. Hence β will be decreased. For BE the changes are in the reverse direction and the value of β will be increased. By a little trial adjustment the form of the curve may be so modified as to give within limits any desired value of β.

84 If now we suppose the form of chamber corresponding to the curve OAC to be determined, then it is evident that the areas $OABD$ and $OABE$ will differ but slightly from $OABC$. Hence to a first approximation R and $\alpha\beta$ in [30] and [31] will remain the same while α will vary inversely as β. It will result that the values of v and hence of b $(v^2 - v_1^2)$ will remain sensibly the same and hence that the change in the values of y, equation [22], will be determined by the change in the term $a \dfrac{dv}{dt} = a\alpha z$.

85 The new value of the surge, [41] or [42], is also quickly found as well as the values of n for the beginning and one or two other points on the curve by [37] and [38]. If these indications justify, the form and dimensions of the chamber may then be developed in detail by the regular treatment of the new curve $OABE$ or $OABD$.

86 Referring further to the area at the level for $T = 0$ it appears from [38] that in such a case the value of n will vary directly as β^2 and hence for chambers of similar forms corresponding dimensions will vary directly as β. The resulting change in area or diameter of chamber at the level where $T = 0$ is thus apparent. If it is desired to hold the upper diameter or area within some specified limits, the slope of the curve may be correspondingly modified. Thus, if the change is in the direction BE the result will be an increase in the values of β and of the diameter of chamber where $T = 0$, both sensibly in the same ratio. If at the same time, however, the slope of the curve at the origin is increased, as indicated by the dotted line, this latter modification will serve to counteract more or less the change due to varying β and hence by adjustment between the two any specified or limiting value of this diameter may be determined.

87 By the aid of [30], [31], [32], [33] the general results of any small modification in the form of the acceleration curve may be analyzed, showing the character of change in the form of the chamber. Thus, in Fig. 10, let the original curve indicated by the full line be modified as indicated by the dotted line. For the purposes of such an analysis the new curve may be divided into the following parts:

OA and DE remaining the same as before
AB with increased negative slope and decreased ordinate
BC with the same slope sensibly and decreased ordinate
CD with decreased negative slope and decreased ordinate.

88 The analysis need not be given in detail. Having in view the direction and relative quantitative amounts of change in the various quantities involved, the changes in the area of chamber will be as follows:

Period Corresponding to	*Change in Area of Chamber*
OA	decrease
AB	from decrease to small and uncertain and then increase
BC	increase
CD	from increase to small and uncertain
DE	small and uncertain

89 There are many other minor points of relationship between the form of the curve of acceleration and the resulting form of the chamber, the amount of surge, the characteristics of the movement of the water, etc., which will occur to anyone dealing with actual problems, but which are scarcely of sufficient importance to warrant further detailed notice. It results, however, that the acceleration curve may by such means be quickly and readily adjusted to develop within limits a chamber of any desired general character of form, and to fulfil any predetermined or specified program as regards the movement of the water surface, extent of surge and time required.

APPENDIX NO. 3

ILLUSTRATIVE CASES

90 Two or three illustrative cases may be drawn from the problem which has given rise to the development of this particular method. This problem is concerned with the control of the water in the Los Angeles aqueduct at one of the power sites where the principal conditions are as follows:

91 The water is to be led through a cement lined rock tunnel a distance of about 41,000 ft. to the power drop whence a penstock of about 3150 ft. in length will lead to the power house. The upper portal of the tunnel is under a positive head varying with the stage of the reservoir but which may be taken at 85 ft. maximum. The total drop through the tunnels is 58.8 ft., made up of two gradients, 26,800 ft. for the first section on a gradient of 0.001 and 14,100 ft. for the second section on a gradient of 0.0023. The fall at the power drop is 808 ft. and the total gross head is $808 + 58.8 + 85 = 951.8$ or 952 ft.

92 The maximum amount of water to be handled is 1000 cu. ft. per sec. and the actual amount will be in accordance with the momentary power demand up to this value as a maximum. The two sections of the tunnel are not of the same size, and the velocities of flow will therefore not be equal. For purposes of preliminary study, however, a uniform conduit of 100 sq. ft. section was assumed, thus giving a maximum velocity of 10 ft. per sec. It thus appears that under maximum conditions the tunnel as a whole will contain some 128.125 tons of water, which moving at a velocity of 10 ft. per sec. would have a kinetic energy of 200,000 foot-tons in round numbers. Again, it appears from computations which need not be here repeated that without the aid of a surge chamber in developing an acceleration head the time of acceleration from a flow of 600 cu. ft. per sec. to 990 cu. ft. per sec. when 1000 ft. are called for would be some 40 to 50 seconds. To relieve the conditions which would result from the acceleration or retardation in this manner of the 7.76 miles of water column during periods of change for both demanded and rejected load, a surge chamber of cement lined rock excavation, preferably of conical or vase-like form, is contemplated at the end of the lower tunnel and at the top of the power drop.

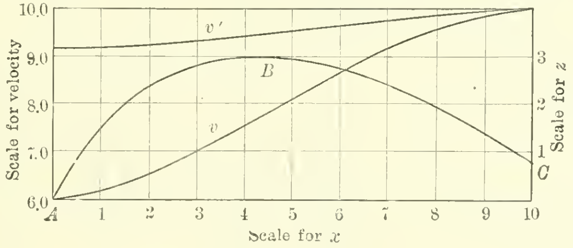

Fig. 11 Diagram showing Type Curve of Acceleration with Resulting Velocities plotted on Time

93 Many alternative studies have been made for this chamber based on a variety of operative conditions. Certain of the preliminary studies based on an assumed uniform section of tunnel may be here used for illustrative purposes.

CASE 1

94 For the numerical coefficients $a = \frac{L}{g}$ and b we have in the present case

$a = 1285$
$b = 1.2$

also

$v_1 = 6.0$
$v_3 = 10.0$

For the friction head

$$h_f = \left(1.2 - \frac{1}{2g}\right)v^2 + 20 = 1.1844\,v^2 + 20$$

also

$$H = 950$$

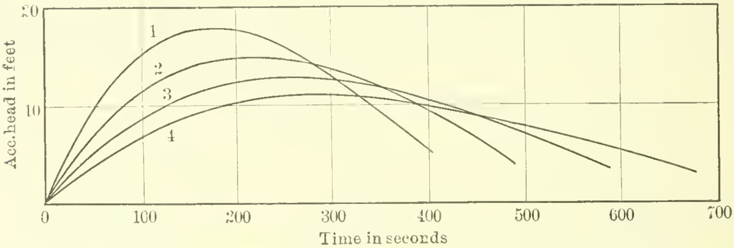

FIG. 12 DIAGRAM SHOWING ACCELERATION PLOTTED ON TIME FOR FOUR DIFFERENT CASES

(1) Acc. head for $\beta = 40.70$
(2) Acc. head for $\beta = 48.95$
(3) Acc. head for $\beta = 58.80$
(4) Acc. head for $\beta = 68.80$

95 For the type curve of acceleration the curve ABC (Fig. 11), was assumed. The numerical values of the ordinates, which we may denote by z, are given in column 2 of Table 1, the scale being entirely arbitrary and these numbers at present having no physical meaning. The assumed curve is first integrated by any of the well known methods and the resulting values placed in column 3. Trapezoidal integration has been used throughout in this preliminary work as will appear from an examination of the values. The total area is 21.415. This is the R of the formulae.

We next find $m = \frac{dz}{dx}$ at the end of the curve by the use of [35]

$$1.93 \times 1 = 1.93$$
$$1.39 \times 4 = 5.56$$
$$75 \times 3 = 2.25$$

Then

$$1.93 + 2.25 = 4.18$$

and

$$4.18 - 5.56 = -1.38$$

The interval $h = 1$. Hence

$$m = -\frac{1.38}{2} = -0.69$$

TABLE 1 TABLE SHOWING TYPICAL FORM OF COMPUTATION

1	2	3	4	5	6	7	8	9
x	z		v	$v^2-v_1^2$	$b(v^2-v_1^2)$	$a\frac{dv}{dt}$	y	$2\frac{dy}{dx}$
0	0	0	6.000	0	0	0	0	18.100
1	1.47	0.735	6.139	1.688	2.026	7.320	9.346	19.284
2	2.36	2.650	6.502	6.276	7.531	11.753	19.284	20.263
3	2.83	5.245	6.995	12.930	15.516	14.093	29.609	20.804
4	3.00	8.160	7.547	20.957	25.148	14.940	40.088	20.828
5	2.95	11.135	8.111	29.788	35.746	14.691	50.437	19.953
6	2.73	13.975	8.644	38.705	46.446	13.595	60.041	18.331
7	2.38	16.530	9.134	47.430	56.916	11.852	68.768	15.630
8	1.93	18.685	9.542	55.050	66.060	9.611	75.671	11.560
9	1.39	20.345	9.858	61.180	73.416	6.912	80.328	6.404
10	0.75	21.415	10.060	65.200	78.240	3.730	81.970	0

	10	11	12	13	14	15	16
x	h	$H-h$	v^1	v^1-v	n	D	Y
0	62.64	887.36	9.145	3.145	17.02	45.39	43.20
1	71.96	878.04	9.242	3.103	15.76	43.67	52.55
2	81.82	868.18	9.348	2.846	13.75	40.79	62.48
3	92.05	857.95	9.460	2.465	11.60	37.47	72.81
4	102.40	847.60	9.575	2.028	9.53	33.96	83.29
5	112.61	837.39	9.691	1.580	7.75	30.62	93.64
6	122.07	827.93	9.802	1.158	6.18	27.35	103.24
7	130.67	819.33	9.905	0.771	4.83	24.18	111.97
8	137.45	812.55	9.988	0.446	3.78	21.38	118.87
9	142.01	807.99	10.044	0.186	2.84	18.54	123.53
10	143.59	806.41	10.060	0	.....	.....	125.18

96 We then find by trial, using the equations given in Appendix No. 2, the values $v_2 = 10.06$, $\beta = 48.95$ and $\alpha = 0.003873$. Hence, the total time for the period = 489.5 seconds = 8.16 minutes. The time required on the basis of the assumed curve is thus determined. We have, therefore,

$$\alpha\beta = \frac{v_2 - v_1}{R} = 0.1896$$

We next find by inserting the proper numerical values in [42]

Surge = 5.17

97 Taking the factor $\alpha\beta = 0.1896$ as explained in Appendix No. 2 and using it as a multiplier, we convert column 3 of Table 1 into velocity change, and

adding $v_1 = 6$ we have the velocity history on time as given in column 4. We then find values of $(v^2 - v_1^2)$ as in column 5 and multiplying by $b = 1.2$ we have values of $b\ (v^2 - v_1^2)$ as in column 6.

98 From the value α (Par. 96)

$$a\alpha = 1285 \times 0.003873 = 4.98$$

Using this as a factor, we convert column 2 into values of $a\,\frac{dv}{dt}$ as in column 7.

We then add the values in columns 6 and 7 finding values of y and enter in column 8.

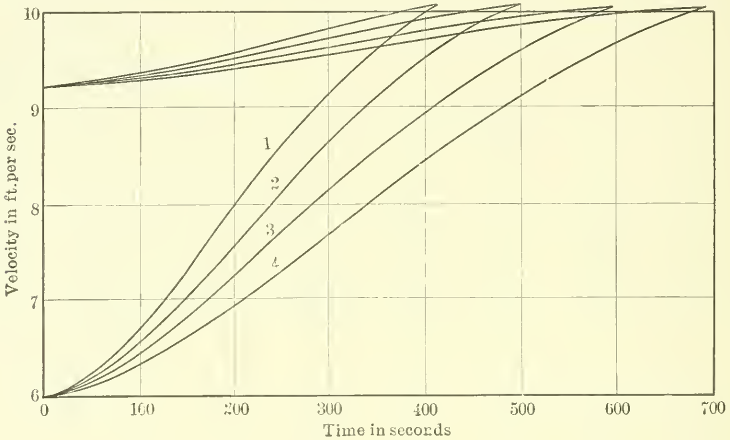

FIG. 13 DIAGRAM SHOWING VELOCITIES PLOTTED ON TIME FOR FOUR CASES AS IN FIG. 12

(1) Velocities v and v^1 for $\beta = 40.70$
(2) Velocities v and v^1 for $\beta = 48.95$
(3) Velocities v and v^1 for $\beta = 58.80$
(4) Velocities v and v^1 for $\beta = 68.80$

99 Next by the use of [33], values of $2\,\frac{dy}{dx}$ for the various points 0 - - - - 9, inclusive, are obtained and entered in column 9. Evidently

$$\frac{dy}{dt} = \frac{2\,\frac{dy}{dx}}{2\beta}.$$

This division by $2\,\beta$ may be taken as a multiplication in the final operation for n as noted below.

100 We next find values of h by adding together values of the acceleration head, column 7, and of $h_f = 1.1844\,v^2 + 20$. These results are entered in column 10 and subtracting them from the gross head, taken here as 950, we have values of $(H - h)$ as in column 11. We then find values of the virtual velocity v^1 by equation [27], Appendix No. 2, and enter the results in column 12. Subtracting v (column 4) from these, we find values of $(v^1 - v)$ as in column 13. Dividing the values in column 13 by those in column 9 and multiplying by

$2\beta = 97.9$ we find values of n as in column 14. These converted into diameter of chamber give the values in column 15.

101 The upper diameter of 45.2 ft., it will be remembered, is for the water level corresponding to a steady velocity of 6 ft. per sec. This will be 43.2 ft. below static level. Hence, adding 43.2 to the values of y in column 8 we find values of Y the distance of the water surface below static level. These are given in column 16.

102 The principal results are shown graphically in Figs. 12, 13 and 14. The dotted line shows the surge chamber slope continued up to the static level

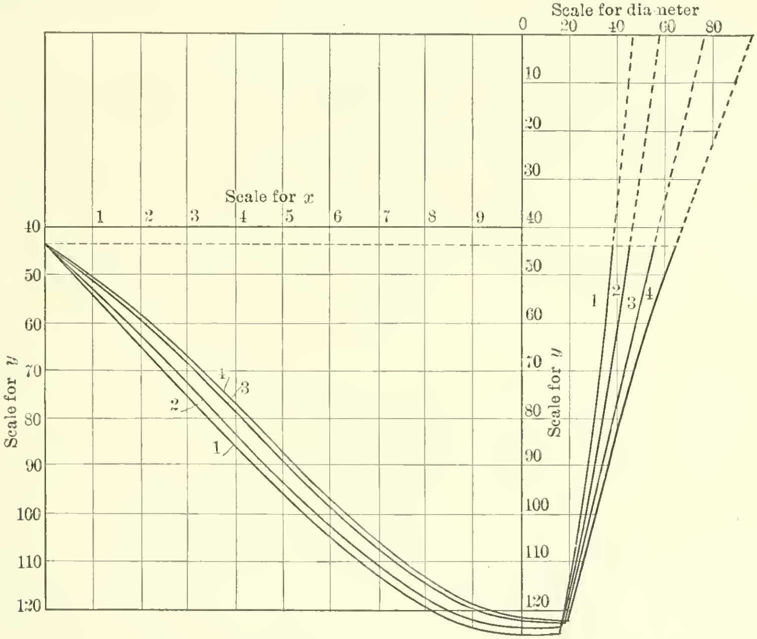

FIG. 14 DIAGRAM SHOWING VALUES OF y PLOTTED ON TIME AND PROFILES OF SURGE CHAMBERS FOR FOUR CASES AS IN FIG. 12

Curves 1 refer to case for $\beta = 40.70$
Curves 2 refer to case for $\beta = 48.95$
Curves 3 refer to case for $\beta = 58.80$
Curves 4 refer to case for $\beta = 68.80$

and indicates, therefore, the general dimensions as some 60 ft. in diameter at the top and 18 ft. at the bottom. Such a chamber then with its given dimensions between the level 43.2 and the bottom would determine for a change in velocity from 6 ft. per sec. to 10.06 ft. per sec., an acceleration and velocity history as indicated, and a maximum fall of water of 81.97 ft. below the level for 6 ft. per sec. steady conditions. This is 125.17 ft. below static level and 5.17 ft. below the level for 10 ft. per sec. steady flow. The surge is therefore 5.17 ft. as previously determined.

103 We may next illustrate the determination of the value of n for $x = 0$, $x = 3$ and $x = 9$ by the use of [37] and [38]. For $\left(\frac{dz}{dx}\right)_0$ we use [34], giving

$$\frac{dz}{dx} = 1.76$$

Then from [38] we have

$$n_0 = \frac{21.415 \times 2396.6 \times 3.145}{4.06 \times 1285 \times 1.76} = 17.35$$

and $D = 46.0$. Likewise for $x = 3$ we find $\frac{dz}{dx} = 0.32$ and substituting the values in [37] we find $n = 11.33$ and $D = 37$. For $x = 9$ we find

$$\frac{dz}{dx} = -0.59$$

$$n = 2.76$$

and

$$D = 18.3$$

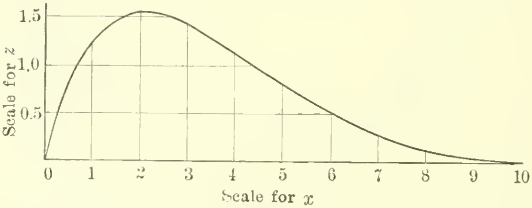

Fig. 15 Diagram showing Type Curve for Non-Oscillatory Movement

104 These various results agree as well with those of Table 1 as could be expected considering the open spacing of ordinates and trapezoidal integration. With closer spacing of ordinates and the use of parabolic rules for integration the difference between the two sets of results will become a vanishing quantity.

105 Suppose next the end of the acceleration curve raised as shown by dotted lines giving to z values as follows:

$$z_8 = 1.95$$
$$z_9 = 1.45$$
$$z_{10} = 0.85$$

We then find

$$\left(\frac{dz}{dx}\right)_{10} = -0.65$$

and

$$\beta = 40.7 \text{ seconds}$$

106 We may assume that the values of R and of v_2 for the transformed curve will differ only slightly from the original values. This assumption will evidently involve no error of significant amount. We may then find immediately the surge from [41] or [42], thus

$$\text{Surge } 1285 \times 0.004658 \times 0.85 + 1.2 \times 1.2 = 6.53$$

107 In the same manner as for the original curve we find by [37] and [38] values of n for $x = 0$, $x = 3$, $x = 9$. For $x = 0$ it is evident from [38] that n varies as β^2.
Hence

$$n_0 = 17.35 \times \left(\frac{40.7}{48.95}\right)^2 = 12.03$$

$$D = 38.2$$

For $x = 3$ we find by substitution in [37]

$$n = 9.14$$
$$D = 33.3 \text{ ft.}$$

For $x = 9$ we have $\frac{dz}{dx} = -0.55$ and we find

$$n = 2.36$$
$$D = 16.9 \text{ ft.}$$

The new value of α will be:

$$\alpha = \frac{0.003873 \times 48.95}{40.7} = 0.004658$$

This will give for the new values of y

$$y_8 = 32.5$$
$$y_9 = 81.7$$

These results give an outline of the size and form of the resulting chamber in Fig. 14.

TABLE 2 PRINCIPAL RESULTS FOR FOUR CASES DERIVED FROM THE SAME TYPE ACCELERATION CURVE

	z_8	z_9	z_{10}	β	Time, Min.	Surge	D_0	D_3	D_9
Original Curve..........	1.93	1.39	0.75	48.95	8.16	5.17	46.0	37.0	18.3
Change 1..................	1.95	1.45	0.85	40.70	6.78	6.53	38.2	33.3	16.9
Change 2..................	1.91	1.35	0.67	58.80	9.80	4.21	55.4	41.2	19.5
Change 3..................	1.89	1.31	0.60	68.80	11.47	3.56	64.8	44.8	20.7

108 If the form of the acceleration curve near the end be slightly modified in the opposite direction, there will result for each change a new case, giving larger sized chambers and larger values of the time. The results of such changes may be determined in the same manner as outlined in Pars. 106 and Par. 107. The principal features for the original and for three changes in the acceleration curve are given in Table 2, and are shown graphically in Figs. 12, 13 and 14.

109 These results for the three changes are of course only approximations, since the change at the end will affect the total area slightly and hence the entire velocity history. The more exact values may of course be formed by going through the case in the regular manner. Assuming the change in the acceleration curve small, however, the errors will be small, and the values found in Table 2 will give a closely approximate idea of the general results as to time, extent of surge and size and form of chamber.

TABLE 3 VALUES OF ORDINATES OF CURVE IN FIG. 15

x	z	x	z
0	0	5.5	0.55
0.5	0.80	6.0	0.42
1.0	1.22	6.5	0.30
1.5	1 44	7.0	0.22
2.0	1.50	7.5	0.16
2.5	1.44	8.0	0.12
3.0	1.30	8.5	0.08
3.5	1.14	9.0	0.04
4.0	0.98	9.5	0.01
4.5	0 83	10.0	0.
5.0	0.68	....	....

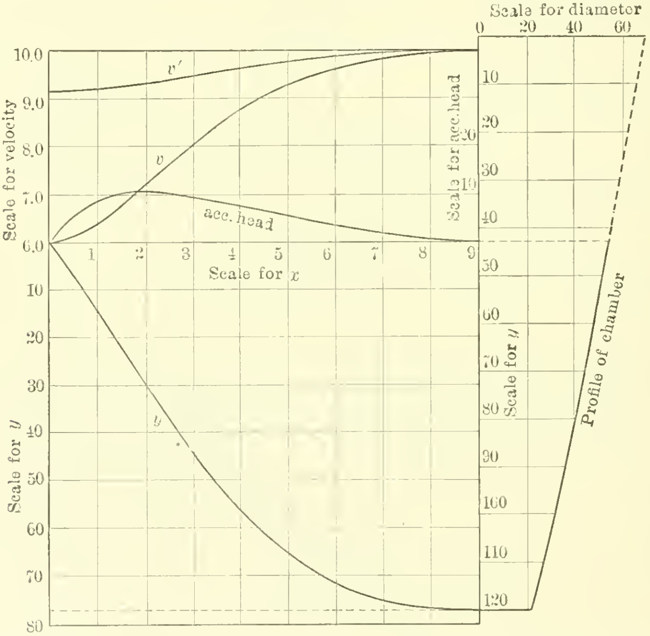

Fig. 16 Diagram showing General Results for the Acceleration Curve of Fig. 15

Curves showing results for case with vanishing value of surge. Value of $\beta = 102.8$.

Case 2

110 As an illustration of a case of practically non-oscillatory movement' reference may be made to the acceleration curve of Fig. 15 where the portion employed is that lying between $x = 0$ and $x = 9$. The value of the ordinates of this curve are given in Table 3.

111 The general method is exactly the same as for the preceding cases and need not be developed in detail. The principal results with the form and dimensions of the chamber and the graphical history of certain of the quantities are shown in Fig. 16.

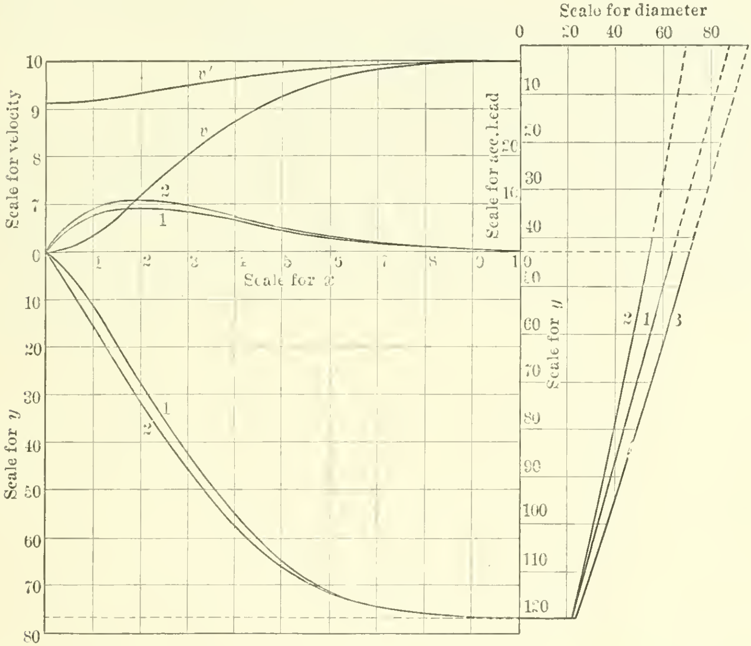

Fig 17 Diagram showing General Results for Non-Oscillatory Movement with Acceleration Curves as shown

Curves 1 refer to case for $\beta = 120$
Curves 2 refer to case for $\beta = 108$
Curves 3 refer to case for $\beta = 120$ and neglecting governor control

Case 3

112 If the entire extent of the curve in Fig. 17 be used, the value of β becomes indefinite as we have seen. If we assume $\beta = 120$ seconds, we may then work through the case as before. The results for such a case are shown graphically in Fig. 17. The time is 20 minutes and the surge is zero by condition.

113 In order to determine the minimum time and the minimum size of the chamber with which the surge, with this form of acceleration curve, may still be kept near the vanishing point, we substitute in [43] the values for the curve at $x = 9$ and find $\beta = 108$. This gives a time of 972 seconds or 16.2 minutes

within which the water level will descend 76.8 ft. while the velocity will rise from 6 ft. per sec. to 9.988 ft. per sec. This is a substantial fulfilment of the conditions as required. If the velocity goes on to 10 ft. per sec. the water level will fall below the level for steady motion with $v = 10$, and an infinitesimal surge will result. The form and dimensions of the chamber corresponding to this condition are shown in Fig. 17.

CASE 4

114 This case is the same as Case 3 with $\beta = 120$ except for the omission of the governor control. The rate of penstock flow is taken as the equivalent of a velocity of 10 ft. per sec. in the main conduit throughout the entire period. The simplification in the numerical work will be readily apparent without detailed description. The results are shown in Fig. 17.

POWER AND HEAT DISTRIBUTION IN CEMENT MILLS

By L. L. Griffiths

ABSTRACT OF PAPER

A comparison is made in this paper of the methods used and the results obtained in five different cement plants for converting the thermal power of the fuel into productive mechanical work. A brief description is given, both of the power installation and of the mill arrangement; and the relative efficiencies of different raw materials, types of grinding machinery and engineering arrangements are considered. The data are such as to enable comparisons to be made between the same types of machinery, and in most cases, the same size and make of machinery, at least in individual departments, if not throughout the entire plant.

POWER AND HEAT DISTRIBUTION IN CEMENT MILLS

By L. L. Griffiths, Cement, Dallas Co., Tex.

Member of the Society

This paper considers the methods employed in cement mills for converting the dormant thermal power of fuel into active and productive mechanical motion. It has been the good fortune of the writer to have been in direct charge of several manufacturing plants and data are given with reference to five cement plants which use the thermal power of fuel in different ways.

2 The primary means of developing this thermal power of a fuel is by means of the application of the heat evolved either by total or partial combustion. If by total combustion, the first means commonly employed for the first stage of the power transmission is steam, either saturated or superheated. The prime mover actuated by this steam, whether it be a reciprocating engine or a turbine, is the second step of the power transmission. Then we have the further transmission of this power through means of belted, geared or direct connection of this prime mover to a lineshaft, thence by means of further belts, gears, ropes or chains from the lineshaft to the machine finally operated. Or we have the prime mover actuating a generator from which the power in changed form is transmitted through wires to motors operating the machines either by direct connection or by means of lineshafting, belts, gears, ropes or chains.

3 Where the first stage is the partial combustion of the fuel resulting in the production of an explosive gas, the prime mover then is an internal-combustion engine connected similarly to that described above.

4 In considering the several plants as set forth in Table 1, a brief description is given both of the power installation and the mill

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arrangement, since there is a considerable difference of opinion as to which form of power consumption is the most economical type for crushing, grinding and pulverizing machinery.

5 The item of fuel herein considered as the source of power, is roughly 30 per cent of the manufacturing cost of a barrel of cement and each barrel of cement manufactured represents the conversion of from 2,000,000 to 3,000,000 B.t.u. Of this total amount, 25 per cent is used in the generation of power in the actual mechanical operation of the machinery of the plant, so that it may readily be seen that the means of converting and transmitting this power is worthy of study and consideration.

PLANT No. 1 A 1000-BBL. PLANT NOMINAL CAPACITY

6 When operating 100 per cent of the machinery 100 per cent of the time the daily output of plant No. 1 would be 1000 bbl. of Portland cement. Briefly, its general arrangement is as follows: Stone from the quarry in man-size pieces is crushed in a gyratory crusher, dried in a rotary drier, further reduced in rolls and finished pulverized in Fuller mills. The raw material is burned in rotary kilns, and the cement clinker prepared for pulverizing by passing through toothed crushers and pulverized in 30-in. Griffin mills.

7 The boiler equipment of the power plant consists of three horizontal tubular boilers of 75 h.p. each, four horizontal tubular boilers of 100 h.p. each and one B. & W. water tubular boiler of 340 h.p. The ash-pits of all the boilers are equipped with McClave steam blowers with steam pressure at 100 lb. They are using West Virginia bituminous slack or run of mine, but its use is uneconomical because the grates are set for hard coal. About 60 per cent of the raw end of this plant is driven by an 18 in. by 40 in. Wright noncondensing engine and the balance or 40 per cent of the raw end, and 100 per cent of the finishing end, is driven by a 20 in. and 34 in. by 42 in. tandem compound Corliss engine operating at 100 r. p. m. in connection with a jet condenser and cooling-tower installation. The kiln room is operated by one 11 in. by 11 in. Buckeye noncondensing 150-r.p.m. engine. With this power installation the plant turns out a barrel of cement for 0.839 h.p.

PLANT No. 2 A 1200-BBL. PLANT NOMINAL CAPACITY

8 Plant No. 2 of 1200-bbl. nominal capacity, operates at an output better than 100 per cent because of the excellence of the operating force. The general arrangement is as follows: Stone from the

quarry is crushed in gyratory crushers of the same make and size as in plant No. 1, dried in a rotary drier, also of the same make and size as in plant No. 1, but the material is now ground in ball mills and is finished pulverized in tubemills, then burned in kilns of the same size as those of plant No. 1. The cement is prepared for pulverizing and is pulverized as in plant No. 1.

9 The boiler equipment of the power plant consists of eight double-drum elephant boilers each of 150 h.p. capacity. The furnaces are equipped with balanced-draft burning Buckwheat anthracite coal. The raw end of this plant is driven by one 20 in. and 36 in. by 42 in. cross-compound condensing Corliss engine operating at 87 r.p.m. The finishing end is driven by a duplicate of this engine, and the kiln room is operated by one 11 in. by 18 in. Buckeye 150-r.p.m. noncondensing engine. The coal house, the handling, drying, crushing and pulverizing coal for kiln fuel is operated by one 11 in. by 10 in. vertical Westinghouse 230-r.p.m. steam engine, and one 20 in. by 16 in. Westinghouse 250-r.p.m. engine. This plant produces a barrel of cement on 0.835 i.h.p.

PLANT No. 3 A 2000-BBL. PLANT NOMINAL CAPACITY

10 Plant No. 3 is a more recently constructed plant than either No. 1 or No. 2 and is laid out in a somewhat better manner. This fact together with a more efficient working force, results in an output better than the rated output of 100 per cent. The crushing, grinding and pulverizing machinery of the raw ends, kilns and auxiliaries of the burning department, and crushers and pulverizers of the finishing end, were the same as in plant No. 2, a greater number of the same size units being used for the increased capacity.

11 The boiler equipment of the power plant consists of seven 350-h.p. B. & W. boilers fired by Westinghouse stokers using anthracite pea coal, both coal and ashes being automatically handled by conveyors and elevators. The boilers are also equipped with superheaters and the raw end is operated by one 20 in. and 40 in. by 54 in. cross-compound Corliss condensing engine of 74 r.p.m. The finishing end is operated by a duplicate of this engine, and the kiln room by one 16 in. and 28 in. by 42 in. tandem compound Corliss condensing engine at 85 r.p.m. The coal house is operated by one 12 in. and 24 in. by 42 in. tandem compound Corliss condensing engine of 80 r.p.m. This plant produces a barrel of cement on 0.777 i.h.p. The prime movers in every instance are belted to a main

lineshaft, the individual machines being in turn driven from this lineshaft by belt, chain, rope or gear drives.

12 These three plants are known in the cement business as direct-driven plants: that is, in such plants the prime mover is belted to a lineshaft and the individual machines are in turn driven by belts, gears, chains, etc., from this lineshaft. Plants Nos. 4 and 5 are known as electrically-driven plants.

PLANT No. 4 A 2000-BBL. PLANT NOMINAL CAPACITY

13 Plant No. 4 with a nominal capacity of 2000 bbl., although a comparatively new plant, has never been operated at better than 60 per cent of its nominal rating, due to a very poor arrangement of mixing, conveying and pulverizing machinery. On account of the load condition, however, the electrical efficiency is high in that the motors are operating at from 100 to 125 per cent full load: and the maximum efficiency of the induction motor is at about 120 per cent rated load.

14 The general arrangement of this plant is as follows: Stone in man-size pieces is reduced by passing it through two gyratory crushers; the shale is reduced by passage through toothed rolls. It is dried in a rotary drier, mixed with limestone and further reduced with it in a Williams mill. The material is then passed through two rotary mix driers to 30-in. Griffin mills used as preliminaries to tube-mills, in which the raw material is finished. This is burned in kilns of the same size as those in the No. 2 and No. 3 plants. The clinker is prepared by passing through a toothed crusher and rolls, and pulverized in 30-in. Griffin mills.

15 The boiler equipment of the power plant consists of two 250-h.p. Cahall vertical boilers, four 250-h.p. O'Brien-Heine boilers, and one 375-h.p. O'Brien-Heine boiler. The fuel used is Southern Indiana bituminous coal and with the exception of the Cahall boilers, the setting and grates are for hard coal. The furnace efficiency is therefore low. The prime movers in this plant are two vertical Curtis turbines, one direct connected to a 1000-k.w. three-phase, 25-cycle, 440-volt alternator, and the other to an 800-k.w. alternator. Each individual machine throughout the plant is driven by an individual motor of proper size by a belt from the motor pulley to a shaft and from the shaft to the machine either by gears, belt, or chain drive. This plant consumed 1.26 h. p. per bbl. of cement produced.

PLANT No. 5 A 2500-BBL. PLANT NOMINAL CAPACITY

16 Plant No. 5 comes under the same heading as plant No. 4, but is unique in that it is the only one which starts with partial combustion of the fuel, and discarding steam as a means of power transmission between the fuel bed and the prime mover, uses the gas direct from the fuel in an internal-combustion or gas engine. Due to the difficulty of mixing and combining the raw materials of the section in which the plant is located it is operating at about only 80 per cent of its capacity at the output figures given. The basis of comparison therefore, for the grinding, pulverizing and burning machinery, which is operating on cement rock in the Lehigh Valley, is not a fair one.

17 The stone is loaded with a steam shovel, crushed in a gyratory crusher, further reduced in a Williams mill, and dried in rotary driers. The shale or clay is loaded with a steam shovel, run through a dry pan mill, dried, and meets the stone at the weigh bin where the mixture is proportioned. It then passes through a rotary mixer to ball mills and is finished in tubemills, burned in rotary kilns, and the cement clinker then crushed in ball mills and finished in tubemills.

18 Electrically, the conditions are practically the same as those described for plant No. 4.

19 The power plant consists of six up-draft producers in place of the usual steam boilers, the generating gas operating three 34 in. by 48 in. horizontal tandem gas engines driving three 750-k.w. three-phase, 25-cycle, 440-volt alternators.

20 It may appear that this paper emphasizes the relative efficiencies of different raw materials, types of grinding machinery and engineering arrangements. The presence of these as variables is admitted, especially when the plants cited are in different localities, but fortunately we have exactly the same types of machinery and in most cases the same size and make in the comparisons given, if not throughout the entire plant at least throughout entire departments which represent the several stages in the manufacture of cement from the raw materials.

21 In explanation of the lettering of the different departments in Table 1 the quarry is considered as A; preliminary crushing, secondary breaking down and storing of the raw materials as B_1; the drying, grinding and pulverizing of the raw material as B_2; sub-divisions, B_1 and B_2 as the raw end B; burning the raw material to cement clinker and cooling it as department C; crushing, grinding and pulverizing the cement clinker as department D, — D_1 being the preliminary crushing and grinding, and D_2 the finishing or pulverizing.

22 Comparing the figures in Tables 1 and 2 in connection with the brief description of the plants, it is seen that a direct-driven plant shows a power economy greater than an electrically driven plant.

23 Plants Nos. 2, 3 and 5 are comparable in departments B_1 and B_2 with but small opportunity of error in that the size, type and make of the granulating and pulverizing machinery is identical. It will be noted that a barrel of finished raw material at the kiln bins department B, consumes as follows:

	I. H. P.	
	Total	Per Bbl.
Plant No. 1	387	0.403
Plant No. 2	416	0.341
Plant No. 3	602	0.276
Plant No. 4	736	0.626
Plant No. 5	860	0.478

24 Plants Nos. 3 and 4 have twice the number of kilns, feeders for both pulverized coal and raw material, low-pressure air systems, elevators and auxiliaries that plant No. 2 has. Plant No. 5 has the same number of kilns, etc., as plant No. 2, but the kilns have twice the area and length and the auxiliaries are twice as large. We have as a comparison, however:

	I. H. P.	
	Total	Per Bbl.
Plant No. 1	38	0.0396
Plant No. 2	37	0.0303
Plant No. 3	159	0.073
Plant No. 4	86	0.0732
Plant No. 5	170	0.0945

25 In the clinker-grinding and finishing departments D we find a greater difference in the machinery used, that is: when comparing plants Nos. 2, 3 and 5, but the department D of plant No. 4 is comparable with that of plants No. 2 and No. 3 with reference to the grinding machinery used, and we have:

	I. H. F.	
	Total	Per Bbl.
Plant No. 1	300	0.312
Plant No. 2	476	0.390
Plant No. 3	750	0.341
Plant No. 4	531	0.452
Plant No. 5	962	0.534

From the above it will be noted that in practically every instance the direct-driven plant is more economical in power consumption, than the electrically driven plant.

26 In considering this subject it has appeared to me that the pounds of coal used per indicated horsepower do not show the true condition, so the equivalents in British thermal units are given in Table 2.

TABLE 1 DATA UPON THE POWER DISTRIBUTION IN FIVE CEMENT PLANTS

Plant No. 1	1	2	3	4	5
Nominal Capacity, Bbl.	1000	1200	2000	2000	2500
Actual Capacity, Bbl	960	1220	2180	1176	1800
Indicated Horse Power					
Gross Developed	805	1020	1694	1480	2430
Cement per Bbl	0.839	0.835	0.777	1.26	1.35
Hours, per Bbl	20.15	20.04	18.65	30.75	32.4
Coal Cost, per Ton	$2.76	$2.12	$2.45	$1.25	$1.50
Cost Coal, Cents per H p-hr	0.00655	0.00325	.00411	0.00119	0.0019
Lb. per H.p.	5.32	3.44	3.8	6.7	2.87
Proportion to Departments					
B_1, H.p.	......	......	......	189	136
%	......	......	......	12.7	5.6
B_2, H,p	......	......	......	547	724
%	......	......	......	36.8	29.8
B, H.p.	387	416	602	736	860
%	48	40.75	35.5	49.5	35.4
C, H.p	38	37	159	86	170
%	4.5	3.5	9.5	5.8	7.0
D_1, H.p	......	......	......	......	......
%	......	......	......	......	......
D_2, H.p	......	......	......	......	......
%	......	......	......	......	......
D, H.p	300	476	750	531	962
%	38	46.75	44.5	35.7	39.6
Coal, Gr.	80	90	183	132	438
%	9.5	9.0	10.75	8.86	18

TABLE 2 HEAT UNITS PER I. H. P. PER BARREL CEMENT

Plant No.	Coal, Lb. per I.H.p.-Hr.	B. t. u. per I.H.p.-Hr.	Power Coal, Lb. per Bbl. Cement	B. t. u. per Bbl. Cement
1	5.32	71,022	107.19	1,430,960
2	3.44	40,560	68.94	792,782
3	3.80	45,600	70.87	850,440
4	6.7	82,745	200.03	2,470,308
5	2.87	21,094	92.99	683,462

27 From Table 2 it appears that the power plant No. 5 using the most direct method of transmitting the thermal power of the fuel to the prime mover, i.e., by means of the gas generated by partial combustion of the fuel in a producer, shows the lowest B.t.u. consumption and highest thermal efficiency, but on account of the losses inherent in the balance of the power transmission system, uses more i.h.p. per bbl. of cement produced than do plants Nos. 1, 2, 3 and 4. The same is true of plant No. 4 as compared with plants Nos. 1, 2 and 3, from which it appears to me that in addition to all of the losses inherent in a direct-driven plant, the electrically driven plant has in addition those decreased efficiencies representing losses in the conversion of mechanical power to electrical power and back from electrical power to mechanical.

28 We have for instance in plants Nos. 1, 2 and 3 the fuel fired under boilers, generating steam which in turn is used in the engines giving motion and power to the lineshaft. Through the aid of a belt this power is then transmitted to the several machines by means of belts, gears, chains, ropes, etc. In this arrangement we have the losses shown in column 1 below.

29 In plant No. 4 the fuel is fired under boilers, and steam is used in the turbine to generate electrical current in the alternators, the current produces motion and power in the motors which is transmitted to the machines, through a belt to a counter-shaft, and thence by belt, gearing, chain or rope to the machine, and the losses are as shown in column 2 below.

30 In plant No. 5 the fuel is fired into a producer which supplies gas to an engine operating an alternator generating current from which point the cycle is the same as in plant No. 4, and the losses are as shown in column 3 below.

	Plant Numbers	
1, 2 and 3	4.	5.
Furnace	Furnace	Producer
Boiler	Boiler	Engine (gas)
Engine	Engine (turbine)	Generator
Belting	Generator	Line
Lineshaft	Line (circuits)	Motor
Lineshaft	Motor	Belt
Belting	Belt	Lineshaft
	Lineshaft	Belt
	Belt	

31 The above are all comparable on a monetary basis, but time and space will not permit going into this. It is appreciated that given a water-power proposition, that the proper installation is a hydro-electric one, but it is believed that the most economical cement plants of the future, that is, from a power consumption standpoint, will be developed along the lines of a producer as the first step in the cycle of power conversion and transmission; then an internal-combustion engine operating the main departments direct connected to the lineshaft, and the waste heat from these engines utilized in an exhaust or low-pressure steam turbine operating direct-currrent generators, which current so generated will be used for lighting and the operation of isolated and remote machines.

QUANTITY MANUFACTURE OF SMALL DEVICES

By F. P. Cox

ABSTRACT OF PAPER

This paper deals with the production of small but not particularly complicated devices. It assumes that the apparatus has been properly designed for economical manufacture, and discusses the organization of the shop.

The author considers it essential that change of design, except at stated periods, should be avoided; that the responsibilities of the different assistants should be sharply defined, and should not overlap; that stock handling is of the greatest importance in order to avoid interference with the labor cost, and that the chief function of an organization is to assist the workman to perform a maximum of work with a minimum of effort. Recognizing and fully believing in scientific management, he contends that an organization should be sufficiently flexible that ability in whatever form it may be found may be used to advantage, and in no case should the man be sacrificed to the system.

QUANTITY MANUFACTURE OF SMALL DEVICES

By F. P. Cox,[1] West Lynn, Mass.

Non-Member

The economical manufacture of small devices in large quantities is chiefly characterized by the attention which must be given to details. The cost of material is in general proportionally small, and in any case more or less fixed by the design; but the labor item is large and requires constant and careful scrutiny. Unlike other lines of manufacture, each operation is repeated over and over again and, therefore, warrants a considerable expenditure of time and money to determine exactly the best manner in which to perform it. It is desirable to know just how economically it can be performed even though temporary conditions prevent an immediate realization of possible results.

2 This leads to scientific rate setting, and the advantages of such an experimental manufacturing department are too well known to require comment. It means automatic machinery for many operations, but not for all; it means suitable provision for stock handling, inspection, supervision, etc. Each of these subjects, if covered completely, would require an individual paper. In addition, it requires organization to provide for the proper correlation of these various elements and to insure their harmonious operation.

3 Many plans of organization along the same general lines are possible. The general lines are subject to variations at times, but they are all centered around the same principal object, the labor item. No manager will ever be able fully to realize his ideal system, and perhaps the chief reason will be found in the limitations of his assistants. An organization which has been in operation for any length

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of time will have developed a certain number of individualities which must be reckoned with in any contemplated change. It would be folly to dispense with a man of proved value because he doesn't happen to fit exactly in an ideal plan of organization. It is always possible to modify the system to avoid such a sacrifice and without any material departure from the original scheme.

4 An equivalent system can be devised with comparatively little difficulty, but the equivalent of a tried man is hard to find. Of course this does not mean that a weak man should be retained, nor that one not in sympathy with the plan of organization should be permitted to take part in its administration. Neither does it mean that any effort should be spared to find and employ a competent man to fill an important part in the general scheme. It does mean, however, that a man whose known limitations prevent him from filling all the duties of a certain position should have those duties so modified that he will not be prevented from filling those for which he has been found particularly adapted; and that one who has shown particular ability in handling two or more lines, not originally intended to be combined, may still exercise this talent by a reasonable modification of the system.

5 The organization here outlined probably differs very little from similar organizations intended to cover the same field.

Manager
  a Superintendent
    (1) Production clerk
    (2) Stock clerk
    (3) Material list department
    (4) Rate setting department
    (5) Automatic tool department
    (6) Shop accountants
    (7) General foreman
    (8) Inspectors
    (9) Tool department
  b Engineer
    (1) Designer
    (2) Draftsmen
    (3) Model room
  c Cost department

6 The strength of this organization lies in the fact that each feature of manufacture is under control of a man particularly qualified

to handle it in the best possible manner, and that his responsibility is definitely fixed and limited to the proper performance of his own part of the work. There is no overlapping of responsibility and no possibility of misunderstanding. Any failure to produce a part is at once traced to the responsible party. For example, if a leading-hand finds that he is not receiving his parts in adequate numbers and is, consequently, handicapped, he at once reports to the stock clerk who has failed in his duty. The stock clerk realizes that he has failed. The mere absence of parts is convincing evidence of the fact, and he must correct the shortage before it becomes a limiting feature or report his inability to do so to the superintendent.

7 In this way, the superintendent is constantly advised of matters which are liable to interfere with his business, and is able to apply corrective measures before the situation is serious.

8 When everything is moving properly, if such condition should ever exist, the work of the various departments becomes routine, but the moment any trouble appears in the distance, an alarm is sounded. If trivial in character, it is corrected without any great disturbance, but if important, it comes at once to the highest authority and the whole strength of the organization is applied promptly to correct it.

9 The functions of the different departments are, in general, sufficiently described by their names. It may be necessary to add that all material is ordered by the material list department, but the following of the stock into and through the shop rests with the stock clerks, and that while the inspectors come under the superintendent, the limits of inspection are set by the engineers.

10 The workman is the principal subject of study and every effort must be made to shorten the time and lessen the effort required to perform the operation for which he is engaged. It may mean automatic tools, increased facilities, improved methods, or the splitting of the operation so that a portion of it may be done by a less skilled operator, who is competent to do this portion in a satisfactory manner.

11 Always inspection is involved in order that no time may be spent on a piece which is already defective and will ultimately be rejected or require special fitting, which is necessarily expensive. The proper time to reject a piece or to correct it is immediately after the false operation has been completed.

12 In order that a workman may perform a maximum of work with a minimum of effort, it is necessary that the piece shall come to him in ample quantity and at a constant rate; that previous operations shall have been properly performed, and that the piece shall be

promptly inspected and removed. His whole thought and effort should be given to performing his own operation satisfactorily. One portion of this desired result may be obtained by a large stock of parts, but this means unnecessarily large inventory, and should be rejected. It is just as necessary that parts should not wait for the workman as it is that the workman should not wait for parts.

13 Regular and frequent meetings are held by the superintendent and his assistants, so that each may be familiar in a general way with conditions as a whole, but such meetings are not to be construed as lessening the responsibility of the different departments. These meetings require but little time if everything is going smoothly, and justify the time taken if there is any prospect of trouble.

14 Similar meetings are held weekly by the manager, engineer and superintendent, and are more or less generally attended by principal assistants. Change of design or method are freely discussed at these meetings, and they serve as a clearing house for all matters of interest which have come up during the week and which are not of sufficient importance to require instant attention.

15 Changes of design, unless to correct defects in the apparatus are docketed and not acted on singly as they arise. Low costs cannot be obtained where the design is continually changing, and minor changes should be held for an apparatus meeting. Such meetings are held at regular intervals of from three to six months. When a line of apparatus has but recently been placed in the shop, the interval is shorter than when it has become more firmly established and original troubles eradicated.

16 Apparatus meetings are attended by the manager, engineer, cost department and superintendent, with their assistants who have the actual handling of the apparatus. The device is placed on the table and gradually dissected, each part being fully discussed as it is taken off, and the presence of the leading hand is considered essential during the discussion of the particular part or operation with which he is concerned. The leading-hand, or gang boss, comes under the general foreman. He has direct charge of a rather small number of operators, and often a portion of his time is given to productive labor. More than anyone else he appreciates inconveniences and difficulties which arise in producing his particular part, and any organization which fails to profit by such knowledge is fundamentally defective. Introduction of automatic tools, change of methods or of design, and quality of product are thoroughly gone into and after this meeting all changes decided upon are authorized at one time after which none are made until the next change period.

GENERAL NOTES

AMERICAN INSTITUTE OF MINING ENGINEERS

A meeting of the American Institute of Mining Engineers will be held in San Francisco, Cal., October 10 to 16, 1911. There will be the usual sessions for the reading and discussion of technical and professional papers, and the local committee is considering a number of excursions in and about the city, including the Oil Fields, Gold Dredges, Mt. Tamalpais, the Lick Observatory, Mt. Hamilton, and possibly longer trips to Grass Valley, Nevada City, and the Mother Lode district. As an added attraction, it is proposed to organize a preliminary excursion by a special train *de luxe* from Chicago to San Francisco, and return to Chicago after the conclusion of the meeting. On the outward trip a day or two each will be spent at the Grand Canyon of Colorado in Arizona, Los Angeles, Santa Barbara and Del Monte.

In reply to the preliminary notice sent out January 24, 1911, more than 75 members and guests have already announced their intention to attend the excursion of the institute to Japan. The number of the party is limited to 100, and in order to facilitate the completion of the preliminary arrangements, it is urged that all who intend to make the trip signify their intentions at once.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The annual meeting of the American Institute of Electrical Engineers was held in the Engineering Societies Building, New York, May 16, 1911. The main feature of the program for the evening was the ceremonies in connection with the presentation of the Edison medal to Frank J. Sprague. A number of addresses were made indicating the result of Mr. Sprague's work along the lines of electricity in the navy. Among the speakers and subjects were: The Development of the Electric Railway, W. B. Potter, Mem. Am. Soc. M. E. Social Results of the Introduction of the Electric Railway, F. H. Giddings; The Relation of Governmental Control to the Development of Electric Railways and the Electrification of Steam Lines, G. F. Swain, Mem. Am. Soc. M. E. also an address on The Results of the Use of Electricity in the Navy. Calvin W. Rice, Secretary of the Society, attended the meeting as a guest of honor.

The annual convention of the American Institute of Electrical Engineers will be held in Chicago, Ill., June 26 to 30, 1911, with headquarters at the New Hotel Sherman. The following papers will be presented: Economical Design of Direct-Current Magnets, R. Wikander Catenary Span Calculations, W. L. R. Robertson; Currents in Inductors of Induction Motors, H. Wiecshel; Multiplex Telephony and Telegraphy by Means of Electric Waves Guided by Wires, G. O. Squier; Electrolysis in Reinforced Concrete, C. E. Magnusson, G. H. Smith, Mem. Am. Soc. M. E.; Induction Motor Design, T. Hoock; The High

Efficiency Suspension Insulators, A. O. Austin, Mem. Am. Soc. M. E.; The Electric Strength of Air II, J. B. Whitehead; Electrification Analyzed, and Its Application to Trunk Line Roads, W. S. Murray; Telegraph Transmission, F. F. Fowle; The Cost of Transformer Losses, R. W. Atkinson, C. E. Stone; The Cost of Railway Electrification, B. R. Wood; Induction Motor for Single-Phase Traction, E. F. W. Alexanderson; Properties of Iron at 200,000 Cyles, E. W. F. Alexanderson; Electric Magnetic Storage Batteries, B. Ford; The Characteristics of Isolated Plants, P. R. Moses; Elevator Control, T. E. Barnum; and Limits to the Use of Resistance of Materials.

INTERNATIONAL RAILWAY FUEL ASSOCIATION

The annual convention of the International Railway Fuel Association was held at Chattanooga, Tenn., May 15–18, 1911, with headquarters at the Hotel Patten. The following papers were presented: Fuel Investigations under the Bureau of Mines, J. A. Holmes, Mem.Am.Soc.M.E.; How to Organize a Railway Fuel Department and Its Relation to other Departments, T. D. Smith; The Testing of Locomotive Fuel, F. O. Bunnell; Standard Locomotive Fuel Performance Sheet, F. C. Pickard; The Railway Fuel Problem in Relation to Railway Operation, R. Emerson; Petroleum, Its Origin, Production and Use as Locomotive Fuel, E. McAuliffe.

FOUNDRYMEN'S ASSOCIATION

The American Foundrymen's Association, American Brass Founders' Association and the Associated Foundry Foremen held their annual conventions in Pittsburg, Pa., May 23 to 26, 1911. The papers read before the different sessions were: Production Cost, Economic Foundry Insurance, Uniform Contracts, Unloading Methods, Use of Borings in Cupolas, Effect of Alloys in Cast Iron, Permanent Molds, Vanadium in Non-Ferrous Alloys, Determination of Nickel Bronzes, Pouring High Grade Bronzes, Rotary Blowers, Foundry Construction, Heating and Lighting Systems, Pattern Making, Molding Machines, Acid and Basic Open-Hearth Processes, Electric and Converter Furnaces for Steel Castings, Effect of Vanadium and Titanium on Steel, Corrosion of Brass Foundry Products, Pyrometer and the Aluminum Foundry, Non-Ferrous Foundry Economies, Equilibrium Diagrams, Molding Sand, Use of Alloys, Shot in Castings.

IRON AND STEEL INSTITUTE

The annual meeting of the Iron and Steel Institute was held at the Institution of Civil Engineers, London, England, May 11 and 12, 1911. At the opening session the Bessemer Gold Medal for 1911 was presented to Prof. Henry Le Chatelier and the Andrew Carnegie Gold Medal for 1910 to Felix Robin. The awards of the Andrew Carnegie Research Scholarships for 1911 were also announced. Among the papers presented and discussed were the following: On Temperature Influences on Carbon and Iron, E. Adamson; On the Chemical and Mechanical Relations of Iron, Chromium and Carbon, J. O. Arnold, A. A. Read; On the Growth of Cast Irons after Repeated Heatings, H. C. H. Carpenter; On the

Relation of Impurities to the Corrosion of Iron, J. W. Cobb; On Magnetic Properties of some Nickel Steels with some notes on the Structures of Meteoric Iron, E. C. Glauert, S. Hilpert; Notes on a Process for the Dessication of Air by Calcium Chloride, F. A. Baubinè, E. V. Roy; On the Volumetric Estimation of Sulphur in Iron and Steel, T. G. Elliot; On the Action of Aqueous Solutions of single and mixed Electrolytes on Iron, J. N. Friend, J. H. Brown; On Iron-Silicon-Carbon Alloys, W. Gontermann; On the Influence of Vanadium upon Cast Iron, W. H. Hatfield; On the Organic Origin of the Sedimentary Ores of Iron, W. H. Herdsman; On Some Studies on Welds, E. F. Law, W. H. Merrett, W. P. Digby; On the Corrosion of Steel, P. Longmuir, On the Influence of 2 Per Cent of Vanadium on Steels of Varying Carbon Content, A. McWilliam, E. J. Barnes; On Some Properties of Heat-Treated 3 Per Cent Nickel Steels, A. McWilliam, E. J. Barnes; On Mechanicalising Analysis as an Aid to Accuracy and Speed for Commercial Purposes, C. H. Ridsdale, N. D. Ridsdale; On Welding up of Blowholes and Cavities in Steel Ingots, J. E. Stead.

AIR BRAKE ASSOCIATION

The annual convention of the Air Brake Association was held in Chicago, Ill., May 23–26, 1911, the headquarters being at the Auditorium Hotel. Papers presented were as follows: Air Brake Instruction, Rating, T. Clegg, Geo. A. Wyman, H. H. Burns, H. A. Wahlert, T. F. Lyons; Brake Cylinders and Connections, H. A. Wahlert; Adequate Braking Power for Freight Cars, J. P. Kelly; Cost of Maintenance of Locomotive Brakes, W. P. Huntley; Running Triple Valves without Lubricants, L. Leonard; Fibre Stresses in Brake Gear Parts, G. O. Hammond; "P. C." Equipment, W. V. Turner; Steel Pipe vs. Iron Pipe, J. R. Alexander; Recommended Practice, S. G. Down, G. R. Parker, H. A. Wahlert, N. A. Campbell, J. R. Alexander; Friction of New and Worn Brake Shoes on New and Worn Cast Wheels, A. S. Williamson; Breaking-in-two of Trains, S. H. Draper, P. J. Langan.

NATIONAL ELECTRIC LIGHT ASSOCIATION

Among the papers read at the annual convention of the National Electric Light Association held at New York, May 30 to June 2, 1911, were the following: Master and Men, Paul Lupke; Electrical Exhibitions, L. A. Ferguson; Valuation of Properties as Related to Rated, W. F. Wells; Reasons for Variations of Rates under Varying Conditions of Operation, N. T. Wilcox; The Standardization of Electrical Selling, Douglass Burnett; Economies in Operation Possible through Time Study, L. B. Webster, Mem.Am.Soc.M.E.; The Ventilation of Turbo-Generators, R. B. Williamson; Progress and Development in Self-Cooled Transformers, H. O. Troy; Grounding Low-Tension Circuits, P. M. Lincoln, Mem.Am.Soc.M.E.; Recent Improvements in Single-Phase Motors, W. A. Layman; Relation of Motor Load to Central Station Equipment, F. D. Newbury; Utilization of Central Station for Supply of Electricity to Operate Railroads, Fred. Darlington; A New Method of Reducing the Investment in Central Station Boiler Plants, H. A. Wagner; Determining Cost of Production in Steam Properties under Varying Conditions, G. H. Walbridge.

Reports were also presented as follows: Overhead Construction, Library, Rate Research, Section Organization, Underground Construction, Meters, Prime Movers, Electrical Apparatus, Grounding of Secondaries, Governmental Control of Water Power and Lightning Protection, Electricity in Rural Districts, Improved Standards of Industrial Lighting.

NATIONAL ASSOCIATION OF MANUFACTURERS

The annual convention of the National Association of Manufacturers was held at the Waldorf Astoria, New York, May 15 to 17, 1911. Among the labor problems considered were the prevention of accidents and the question of industrial relief. The results of the investigations made in Europe by F. C. Schwedtman and J. A. Emery were presented before the convention. A special feature was made of banking and currency, and the attitude of our manufacturers towards the plans recently proposed of reforming our banking and currency systems were discussed. Other questions of economic importance, such as immigration, industrial education, and a reform of our patent laws, were also discussed.

OHIO SOCIETY OF MECHANICAL ELECTRICAL AND STEAM ENGINEERS

The semi-annual meeting of the Ohio Society of Mechanical Electrical and Steam Engineers was held at Youngstown, O., May 18 and 19, 1911. Interesting excursions were made to the works of the Youngstown Sheet and Tube Company, to the Ohio Works of the United States Steel Corporation, to the General Fire-Proofing Company, the Trussed Concrete Steel Company, the Republic Rubber Company and other works. Among the papers read were: Flue Gas Analysis, J. W. Hays; The Engineering Features of the Columbus Garbage Reduction Plant, I. F. Osborn: Industrial Motor Control, D. Martignone: General Comments Concerning Hydro-Electric Development in Central West, P. M. Lincoln, Mem. Am. Soc. M. E.; Centrifugal Blowers, Dr. Lowestein.

PERSONALS

Through an error, the following statement appeared in the May issue of The Journal: L. B. Alexander was appointed general sales manager of the Bosch Magneto Co. This should read, assistant general sales manager.

T. S. Bailey, formerly chief engineer of the Electric Boat Co., Quincy, Mass., has become associated with The New London Ship and Engine Co., New London, Conn.

Orville G. Bennet, formerly associated with the Okonite Co., New York, has accepted a position with the General Motors Co., Detroit, Mich.

Chas. E. Burgoon has resigned his position as chief engineer of the U. S. Court House and Post-Office Building, Chicago, Ill. and has become associated with H. W. Matthews. They have formed the Burgoon-Matthews Electric Co., Atlanta, Ga.

Harry M. Chamberlain has become connected with the Macker-Tyler Co., Worcester, Mass. He was recently with the N. Y. C. & H. R. R. R., West Springfield, Mass.

Herbert A. Croxton, formerly president and treasurer of the Massillon Iron & Steel Co., Massillon, O., has been appointed president and general manager of the Consolidated Motor Car Co., Cleveland, O.

T. F. Dreyfus has become connected with the Baltimore & Ohio R. R. Co. as motive power inspector, with headquarters in Wheeling, W. Va.

Harry K. English has been appointed secretary of the Ottumwa Iron Works, Ottumwa, Ia. He was formerly associated with the General Electric Co., Chicago, Ill.

D. C. Fenner has left the employ of the Knox Automobile Co., Springfield, Mass., to accept the position of sales manager of the Alden Sampson Manufacturing Co., with offices in New York.

C. E. Hardy has become identified with the Westinghouse Electric & Manufacturing Co., San Francisco, Cal. as industrial engineer. Mr. Hardy was formerly assistant shop superintendent of the manufacturing department of the U. S. Navy Yard, Mare Island, Cal.

Paul L. Joslyn, recently associated with the Nordberg Manufacturing Co., Milwaukee, Wis., has accepted a position with the Union Iron Works, San Francisco, Cal.

John S. Nicholl, formerly with the N. Y. Edison Co. is now associated with Walter B. Snow, Publicity Engineer, Boston, Mass.

Alfred Noble has been elected an honorary member of the Institution of Civil Engineers, being the only American engineer now possessing this distinction.

D. T. Randall has been transferred from the Boston office of Arthur D. Little, Inc., to take the position of resident engineer to organize and direct an engineering department for the purpose of testing the material and the products used by the General Motors Co., Detroit, Mich.

John J. Swan has become identified with the Chicago Pneumatic Tool Co., New York. He was until recently connected with the Keller Manufacturing Co., Philadelphia, Pa.

L. R. Valentine has recently entered the service of Dodge, Day & Zimmermann, Philadelphia, Pa. Mr. Valentine was formerly identified with the Charles Warner Co., Devault, Pa.

Ralph D. Van Valkenburgh has been appointed district sales manager of the Colonial Steel Co., Pittsburg, Pa., in charge of their Chicago office and warehouse. He was recently district manager for the Taylor Iron & Steel Co., Scranton, Pa.

C. von Goeben, formerly located in New York, has assumed the duties of manager of the works of the Payne & Joubert Machine and Foundry Co., Birmingham, Ala.

L. L. Willard has accepted the position of chief mechanical engineer of the Allis-Chalmers Co., Uniontown, Pa.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

Aerial or Wire Rope-Ways, their Construction and Management. By A. J. Wallis-Tayler. *London, Crosby Lockwood & Son, 1911.*

This is a revision of the author's Aerial or Wire-Rope Tramways. Much new matter is added on such subjects as coaling vessels at sea. The work is illustrated and has a good index.

Twentieth Century Sheet Metal Worker. By H. E. Osborne. *Chicago, American Artisan, 1910.*

Distribution of Gas. By Walter Hole. ed. 2. *London, J. Allan & Co., 1909.*

This is the first and only work in any language that deals exclusively with the important subject of distribution of gas. It is reprinted with additions from articles published in the Gas World. The author is superintendent of the Leeds, England, gas mains and distribution department, and has had 30 years' experience in gas distribution. A chapter on fusion and electrolysis has been added to this edition.

Electric Wiring Diagrams. By W. P. Maycock. *London, Whittaker & Co., 1900.* Gift of the Macmillan Co.

This is an abbreviation of the same author's larger work Electric Wiring, Fittings, Switches and Lamps. It is intended as a reference book of connections for all those who are concerned with or engaged in electric wiring. In one small volume of 146 pp. it gives practically all the diagrams in the larger work, but abbreviates the descriptive matter.

Factory Organization and Costs. By J. L. Nicholson. *New York, Kohl Technical Publishing Co., 1909.*

Gas Engine Manual. By W. A. Tookey. *London, Percival Marshall & Co., 1908.*

Die Gasmotorentechnik. Vols. 1–5, 6, nos. 1–9. *Berlin, 1901-1906.*

Handbook for Heating and Ventilating Engineers. By J. D. Hoffman. *Lafayette, Ind., 1910.*

Junior Engineering Society. Record of Transactions. Vols. 1, 1884–1891; Vol. 4, 1893–1894. *London.* Gift of the Junior Institution of Engineers.

New York Central and Hudson River Railroad Company. 42d Annual Report, 1910. *New York, 1910.* Gift of the company.

New York City Board of Water Supply. 3d Annual Report, 1908. *New York, 1908.* Gift of the board.

New York State Education Department. Arbor Day, Forests of New York, 1911. *Albany, 1911.* Gift of the department.

Northwestern University. Annual Catalogue, 1910–1911. *Evanston, 1911.* Gift of the university.

Production and Consumption of Iron Ore and Pig Iron, and the Production of steel, in the United Kingdom and the Principal foreign Countries in Recent Years, and the Imports and Exports of Certain Classes of Iron and Steel Manufactures, so far as the Particulars can be Stated. *London, 1910.*

Railway Statistics of the United States of America for Year Ending June 30, 1910. *Chicago, 1911.* Gift of Slason Thompson.

River and Harbor Improvements Under the Corps of Engineers U. S. Army. By W. H. Bixby. (An address delivered December 8, 1910). Gift of U. S. Army Corps of Engineers.

Society for the Promotion of Engineering Education. Proceedings, Vol. 18. *Ithaca, 1911.* Gift of the society.

Springfield, Mass. Water Commissioners. 37th Annual Report, 1910. Gift of the board.

Straight Line Engineering Diagrams. By Manifold & Poole. *San Francisco, Technical Publishing Co.*

Technical Dictionary in Six Languages. (Deinhardt-Schlomann Series.) Vol. 9, Machine Tools. *London, 1910.*

U. S. Interstate Commerce Commission. Block Signals on the Railroads of the United States. January 1, 1911. *Washington, 1911.*

Vereins deutscher Ingenieure. Zeitschrift, Vols. 6–7, 1862–1863. *Berlin, 1862-1863.*

EXCHANGES

Institution of Civil Engineers. Minutes of Proceedings. Vol. 183. *London, 1911.*

Index of Papers and Subjects Discussed by Railway Clubs from May 31, 1909 to May 31, 1910. *Society of Railway Clubs.*

John Crerar Library. 16th Annual Report, 1910. *Chicago, 1911.*

Verein deutscher Eisenhüttenleute. Mitgliederverzeichnis, 1911. *Dusseldorf, 1911.*

UNITED ENGINEERING SOCIETY

Black Hills, South Dakota. The Richest Hundred Miles Square in the World. ed. 7. *Chicago & Northwestern Railway, 1909.* Gift of T. E. Cassidy.

TRADES CATALOGUES

American Kron Scale Co., *New York,* Bull. no. 2, automatic springless scales. 15 pp.

C. L. Barker, *Norwalk, Conn.* Catalogue J., Barker motors, 28 pp.

Donegan & Swift, *New York.* Boilers, stacks and tanks, 56 pp.; Steam engines, 31 pp.

Erie Pump & Engine Works, *Erie, Pa.* Centrifugal pumping machinery, 32 pp.

Gray Motor Co., *Detroit, Mich.* Gray motors for motor boats, 31 pp.

Watson, Laidlaw & Co., *Glasgow, Scotland.* "Weston" hydro-extractors, 35 pp.; "Weston" centrifugals and accessories for treatment of sugar, 123 pp.

William Sellers & Co., *Philadelphia, Pa.* Locomotive injectors and boiler attachments, 76 pp.

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

097 Assistant to superintendent, concern manufacturing heavy hydraulic tools, centrifugal pumps, heavy machinery and foundry work. The requirements for the position are more in the line of quality of experience, good business ability and capabilities to enforce regulations without creating irritation, than specific engineering qualifications. Location, New Jersey.

098 Representative for leading machine tool concern in middle west, as salesman and specialist. Should have proper knowledge of machine shop methods, able to recommend machines and equipment for increasing output. Technical graduate preferred.

099 Machinery salesman not over 35, reasonably familiar with machinery in general and having some business experience. Would be expected to travel perhaps half of time. Location, New York State.

0100 Chief Draftsman familiar with manufacture of small parts. Location, Massachusetts.

0101 Draftsman qualified to prepare designs for heavy weight electric motor trucks. Location, New York.

MEN AVAILABLE

219 Junior, at present assistant engineer for large concern in Delaware, desires to make a change and locate in or near New York City. Technical education followed by nine years' experience in manufacturing business as draftsman, designer and chief draftsman giving broad training. Would like to correspond with a factory manager needing an assistant who is progressive and familiar with scientific shop methods.

220 Associate, will be open for an engagement June 1. Ten years' experience handling operation of power plant and maintaining shop equipment.

221 Technically trained engineer, experience shop work, machine, pattern, steel, etc.; six years in sales department. Age 34; prefers position in business end or executive position. Several years drafting in conveyor business.

222 Mechanical engineer, at present assistant chief engineer of one of the largest mining and smelting companies in the United States, desires to locate in middle west. Experience covers power plants, engines, mining, milling and smelting machinery in designs and installation, and the supervision of construction of large plants.

223 Stevens graduate, two and one-half years' experience in manufacture and erection of high and low-pressure piping, as erecting foreman and assistant superintendent. Desires similar position.

224 Graduate mechanical engineer, six years' experience in designing and drafting, research and experimental work in steam engineering. At present employed, but desires change with view to advancement.

225 Superintendent or works manager, 20 years' experience in manufacture of machine tools, steam engines, especially turbines and automobiles; open for engagement about May 15. Ten years in charge as general foreman, superintendent and works manager. Only first class proposition will be considered.

226 Member, technical graduate, desires position as sales engineer. Experienced as skilled mechanic, chief draftsman and superintendent of construction of power plant equipment. Four years in New York and one year in Chicago as sales engineer.

227 Mechanical engineer, technical education, six years' experience with blast furnace and gas engine design and construction. Desires a position with blast furnace as superintendent of construction or engineer in charge of design. Age 30.

228 Location New York City or vicinity. Associate, graduate technical institution, 12 years' experience of wide and general character designing and superintending construction of industrial plants, thoroughly familiar with electric street and interurban railway engineering; reporting on valuations and physical conditions.

229 Student, M. E. Cornell 1910, thorough business training with banking institution, experience in drafting and technical work and study of factory conditions. Past year employed in operating end of large steel plant. Desires to connect with manufacturing, contracting or engineering firm in position requiring progressive business ability.

230 Graduate mechanical engineer, at present employed, desires position of responsibility with compressor builders. Nine years' general experience with air compressors builders, design, testing, development of electric driven units, special problems in air and natural gas compression, sales engineering and publicity work.

231 Graduate mechanical engineering; four years' drafting-room experience in railroad motive power department and manufacturing plants, desires position leading to executive responsibility. Will consider position in engineering sales department. Good references.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ALLEN, Benj. T. (1903), Ch. Engr., Harrisburg Fdy. Mch. Wks., and *for mail* 218 S. 13th St., Harrisburg, Pa.

ALMIRALL, Juan A. (1892; 1904), Htg. and Vent. Engr., Dominick and Clarke Sts., New York, and 97 McDonough St., Brooklyn, N. Y.

BENNET, Orville G., Jr. (Junior 1907), Genl. Motors Co., Detroit, Mich.

BENNETT, Geo. L. (1905), 3321 Giles Pl., Kingsbridge, New York, N. Y.

BROWN, William Clinton (1896), Ch. Engr., Humphrey Gas Pump Co., S. A. and K. Bldg., Syracuse, N. Y.

CAPEN, Thomas W. (1883), 280 Britain Ave., Benton Harbor, Mich.

CHAMBERLAIN, Harry M. (1907), Macker-Tyler Co., 31 Central St., and *for mail,* 7 Wachusett St., Worcester, Mass.

CHAPMAN, Harry Burdett (1910), Long & Chapman, Texas City, Tex.

COBLEIGH, Henry R. (Junior, 1904), Internatl. Steam Pump Co., 115 Broadway, New York, and 503 E. 8th St., Brooklyn, N. Y.

COLLINS, B. R. T. (1891; 1901), Mech. Engr. and Power Plant Economist, 19 Congress St., Boston, Mass.

COOLEY, Hugh Nelson (Associate 1910), Rep., Nordberg Mfg. Co. in Southwestern U. S. and Mex., and *for mail,* 500 Upson Ave., El Paso, Tex.

COX, Frank G. (1905; Associate, 1908), Engr., Otis Elev. Co., Dallas, Tex.

CROXTON, Herbert A. (1903), Pres. and Genl. Mgr., The Consltd. Motor Car Co., E. 72d and L. S. M. S., and the Rosamond, 6715 Euclid Ave., Cleveland, O.

DREYFUS, Theo. Frank (Junior, 1903), M. P. Inspr., Baltimore & Ohio R. R. Co., Wheeling, W. Va.

ENGLISH, Harry K. (Associate, 1908), Secy., Ottumwa Iron Wks., Ottumwa, Ia.

ERICSON, John Ernst (1909), City Engr., City of Chicago, and 4627 Kenmore Ave., Chicago, Ill.

FALLON, John (Junior, 1910), with P. R. Moses, 366 Fifth Ave., New York, N. Y.

FENNER, David C. (1906), Sales Mgr., Alden Sampson Mfg. Co., 5 W. 61st St., New York, N. Y., and *for mail,* 705 Ravine Rd., Plainfield, N. J.

GORDON, Henry Decatur (1896), 80 White St., New York, N. Y., and 15a Evergreen Pl., East Orange, N. J.

GORE, Warren W., (1908), Exper. Engr., Fairbanks Morse Mfg. Co., and *for mail,* 636 Prairie Ave., Beloit, Wis.

GREEN, Chas. Henry (Junior, 1905), Cons. Engr., 617 Peyton Bldg., Spokane, Wash.

HARDY, C. E. (Junior, 1902), Industrial Engr., Westinghouse Elec. & Mfg. Co., 165 Second St., San Francisco, Cal.

HARRINGTON, John Lyle (1903), Waddell & Harrington, Orear-Leslie Bldg., and 2927 Forest Ave., Kansas City, Mo.

HEIKEL, Daniel August (1899), Life Member; Mech. Engr., Abo, Finland.

HERSCHEL, Winslow Hobart (1910), 137 W. Swissvale Ave., Edgewood Park, Pittsburg, Pa.

HILL, Edgar Logan (Junior, 1908), Supt., Am. Steel & Wire Co., and *for mail*, P. O. Box 553, Worcester, Mass.

HOWELL, Frank B. (1901), Asst. Genl. Mgr. Sales, Am. Radiator Co., 816 S. Michigan Ave., and 1615 E. 51st St. Blvd., Chicago, Ill.

HUTCHINS, Harry C. (Junior, 1905), Designer, Pub. Service Com., Rm. 207, 51 Chambers St., and *for mail*, 15 W. 107th St., New York, N. Y.

INGALLS, Frederick D. B. (1909), Cons. Mech. Engr., 502-503 Snow Bldg., and 706½ S. Crouse Ave., Syracuse, N. Y.

JOSLYN, Paul L. (1909), Mech. Engr., Union Iron Wks., and 1953 Pine St., San Francisco, Cal.

KENT, Robert Thurston (Junior, 1905), Editor, Industrial Engineering, 90 West St., New York, N. Y., and *for mail*, 535 Church St., Bound Brook, N. J.

KESSLER, Armin Geo. (Junior, 1909), Ball Eng. Co., and *for mail*, 557 W. 9th St., Erie, Pa.

KING, George I. (1901), Ch. Engr., Middletown Car Co., Middletown, and *for mail*, 200 Brady St., Butler, Pa.

KNEIP, Walter F. (Junior, 1904), Engrg. Dept., H. H. Franklin Mfg. Co., and *for mail*, 918 Bellevue Ave., Syracuse, N. Y.

LOCKWOOD, Rutherford T. (Junior, 1904), Asst. Supt. Sone & Fleming Wks., Stand. Oil Co. of N. Y., Kinglands and Meserole Ave., and *for mail*, 144 Milton St., Brooklyn, N. Y.

McGREGOR, Alexander Grant (Junior, 1905), Douglas, Ariz.

MANLEY, Sumner M. (Junior, 1907), Asst. Mech. Engr., The Proctor & Gamble Co., Ivorydale, and *for mail*, Ivy St., Glendale, O.

MASURY, Alfred Fellows (Junior, 1904), Mech. Engr., Hewitt Motor Co., and *for mail*, 10 E. 31st St., New York, N. Y.

MILLETT, Kenneth Ballard (Junior, 1908), 215 Windham Rd., Willimantic, Conn.

MOODY, Herbert A. (1901; 1905; 1910), Cons. Industrial Engr., 178 Devonshire St., Boston, Mass.

MOODY, William O. (1907), Mech. Engr., Ill. Central R. R., and *for mail*, 864 E. 39th St., Chicago, Ill.

MOORE, Allen H. (1902), Genl. Elec. Co., Schenectady, and *for mail*, 579 Western Ave., Albany, N. Y.

MORAN, Daniel E. (1886; 1904), Cons. Engr., 55 Liberty St., New York, N. Y., and Mendham, Morris Co., N. J.

MUELLER, Victor H. (Junior, 1907), Ch. Draftsman, M. W. Kellogg Co., 117 West Side Ave., Jersey City, and *for mail*, 25 Maple Terrace, East Orange, N. J.

NAGLE, A. F. (1880), Cons. Engr., 22 S. High St., Bethlehem, Pa.

ORCUTT, Harry Fred Lee (1900), London Mgr., Birmingham Small Arms Co., Ltd., Small Heath, Birmingham, and *for mail*, Rowington Hall, nr. Warwick, England.

PARSONS, W. Everett (1899), Cons. Engr., 1639 Third Ave., New York, N. Y. and *for mail*, 240 Grafton Ave., Newark, N. J.

PATTISON, Frank A. (1903), Cons. Engr., Centurian Bldg., 1182 Broadway, New York, N. Y., and Colonia, N. J.

PENNINGTON, James H. (1902), 734 Roland Ave., Baltimore, Md.

PENNOCK, George Alger (Junior, 1903), Asst. Supt., Service and Maintenance, Western Elec. Co., Hawthorne, Ill., and *for mail*, Weston, Mass.

RANDALL, Dwight T. (1904), Resident Engr., Arthur D. Little, Inc., 70 Smith Ave., Detroit, Mich.

SAMPSON, Chas. C. (1909), Gas Engr., Ill. Steel Co., Joliet Wks., and *for mail*, 506 Western Ave., Joliet, Ill.

SEAMAN, Edwin H. (Junior, 1908), Ins. Engr. with Underwriters at Am. Lloyds, 123 William St., New York, and *for mail*, Lock Box 6, Wantagh, Nassau Co., N. Y.

SHELDON, Samuel B. (Junior, 1900), 117 Church St., Bethlehem, Pa.

SNYDER, William E. (1900), Mech. Engr., Am. Steel & Wire Co., Frick Bldg., and *for mail*, 1712 Morrell St., N. S.,Pittsburg, Pa.

STRINGHAM, Joseph S. (1903), Pres., Frontier Engrg. Co., 1309 Majestic Bldg., and 275 Seminole Ave., Detroit, Mich.

SUMNER, Harry W. (Junior, 1900), Pres., Rainier Fdy. Co., Stacy and E. Waterway Sts., and 1643 Federal Ave., N., Seattle, Wash.

TIMMIS, Walter S. (1906), Cons. Engr., Marbridge Bldg., 47 W. 34th St., New York, and Avondale St., Brooklyn Manor, Woodhaven. L. I., N. Y.

SWEET, Charles E. (1907), 135 Taylor Ave., Detroit, Mich.

TOLTZ, Max (1904), Cons. Engr., 1614 Pioneer Press Bldg., and 433 Holly Ave., St. Paul, Minn.

TOWNSEND, Harry P. (Junior, 1904), Secy. and Genl. Mgr., The H. P. Townsend Mfg. Co., 10 Hoadley Pl., Hartford, Conn.

VALENTINE, Louis Rossiter, (Junior, 1907), Dodge, Day & Zimmerman, 608 Chestnut St., and *for mail*, 1433 N. 16th St., Philadelphia, Pa.

VAN VALKENBURGH, Ralph D. (1901; Associate, 1905), Dist. Mgr., Colonial Steel Co., 213 W. Lake St., and *for mail*, Hotel Ontario, 620 N. State St., Chicago, Ill.

VON GOEBEN, Carl (1899), Wks. Mgr., The Payne & Joubert Mch. & Fdy. Co., and *for mail*, P. O. Box 930, Birmingham, Ala.

WELLS, J. Barnard (Junior, 1909), Clerk, care Supt., S. P. L. A. & S. L. R. R., and *for mail*, 421 W. Adams St., Los Angeles, Cal.

WERST, Chas. Wm. (1909), Asst. Supt., Lima Loco. & Mch. Co., and *for mail* 1534 Lakewood Ave., Lima, O.

WILLARD, Lewis Leigh (1907; 1910), Ch. Mech. Engr., Allis-Chalmers Co., and *for mail*, care W. J. Rainey, Uniontown, Pa.

WILLIAMSON, Alfred (Junior, 1902), Mech. Engr., Dept. Water Supply, Gas & Elec. 13 Park Row, New York, and *for mail*, P. O. Box 386, Bronxville, N. Y.

WILLSON, Ernest M. (Associate, 1909), Ch. Draftsman, Hart-Parr Co., and *for mail*, 610 Illinois St., Charles City, Ia.

YARYAN, Homer T. (1892), V. P., The Yaryan Naval Stores Co., Toledo, O.

NEW MEMBERS

McKINNON, William R. (Junior, 1910), 5031 National Ave., West Allis, Wis.

DEATHS

CALDWELL, John A., April 7, 1911.
YARYAN, Edward B., April 28, 1911.

COMING MEETINGS

June—July

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published

AMERICAN CHEMICAL SOCIETY

June 28–July 1, annual convention, Indianapolis, Ind. Secy., Chas. L. Parsons, Durham, N. H.

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

June 21–24, annual meeting, Chicago, Ill. Reports by committees on Chemical Engineering Education and Standardization of Boiler Tests. Secy., J. C. Olsen, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

June 26–30, annual convention, Chicago, Ill. Secy., R. W. Pope, 29 W. 39th St., New York.

AMERICAN INSTITUTE OF MINING ENGINEERS

June 6, Glen Summit meeting, Glen Summit Springs Hotel, Glen Summit Springs, Pa. Secy., Joseph Struthers, 29 W. 39th St., New York.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

June 14–16, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN SOCIETY FOR TESTING MATERIALS

June 27–30, annual meeting, Atlantic City, N. J. Secy., Edgar Marburg, Univ. of Penn., Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS

June 13–16, annual meeting, Chattanooga, Tenn. Secy., C. W. Hunt, 220 W. 57th St., New York.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

May 30–June 2, Spring Meeting, Pittsburg, Pa. Monthly meetings: June 3, Philadelphia, Pa.; June 7, St. Louis, Mo.; June 28, San Francisco, Cal. Secy., Calvin W. Rice, 29 W. 39th St., New York.

AMERICAN WATER WORKS ASSOCIATION

June 6–10, annual convention, Rochester, N. Y. Secy., J. M. Diven, 14 George St., Charlestown, S. C.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS

June 16–17, semi-annual convention, Washington, D. C. Secy., J. A. Andreucetti, C. & N. W. Ry., Chicago, Ill.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS

June 19–23, annual convention, Boston, Mass. Secy., P. W. Drew, Wisconsin Central Railway, Chicago, Ill.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS

June 20–21, annual meeting, Cape May, N. J. Secy., G. P. Conrad, 24 Park Pl., New York.

CANADIAN GAS ASSOCIATION

June 22–24, annual meeting, Quebec City, Quebec. Secy., John Keillor, Hamilton, Ont.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION

July 25–27, annual meeting, Chicago, Ill. Secy., L. H. Bryan, D. & I. R. Ry., Two Harbors, Minn.

MASTER CAR BUILDERS' ASSOCIATION

June 19–21, Spring Convention, Marlborough-Blenheim, Atlantic City, N. J. Secy., Jos. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

NATIONAL ELECTRIC LIGHT ASSOCIATION

May 29–June 2, annual convention, New York. Secy., T. C. Martin, 29 W. 39th St.

NATIONAL GAS AND GASOLINE ENGINE TRADES ASSOCIATION

June 20-23, Spring Convention, Detroit, Mich. Secy., Albert Stritmatter, Cincinnati, O.

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION

June 27–29, annual convention, Pittsburg, Pa. Secy., H. H. Norris, Cornell University, Ithaca, N. Y.

SOCIETY OF AUTOMOBILE ENGINEERS

June 15–17, midsummer meeting, Dayton, O. Genl. Mgr., Coker F. Clarkson, 1451 Broadway, New York.

MEETINGS IN THE ENGINEERING SOCIETIES BUILDING

Date	Society	Secretary	Time
June			
1	Blue Room Engineering Society	W. D. Sprague	8.00 p.m.
8	Illuminating Engineering Society	P. S. Millar	8.00 p.m.
8	Institute of Operating Engineers	M. W. Rice	8.00 p.m.
20	New York Telephone Society	T. H. Lawrence	8.15 p.m.
26	National Isolated Power Plant Association	E. D. Fieux	8.00 p.m.

OFFICERS AND COUNCIL

President

E. D. MEIER

Vice-Presidents

Terms expire 1911	Terms expire 1912
CHARLES WHITING BAKER	GEORGE M. BRILL
W. F. M. GOSS	E. M. HERR
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Cornell University	Dec. 4, 1908	R. C. Carpenter	A. W. deRevere	D. S. Wegg, Jr.
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	C. E. Beck	F. H. Griffiths
Leland Stanford Jr. Univ.	Mar. 9, 1909	W. R. Eckart	H. H. Blee	E. L. Ford
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University of Kansas	Mar. 9, 1909	P. F. Walker	W. H. Judy	M. C. Conley
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Univ. of Wisconsin	Nov. 9, 1909	H. B. J. Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska	Dec. 7, 1909	C. R. Richards	W. O. Forman	C. A. Bennett
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Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
State Univ. of Ky.	Jan. 10, 1911	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University	Jan. 10, 1911	W. T. Magruder	H. A. Shuler	H. M. Bone
Washington University	Mar. 10, 1911			F. E. Glasgow

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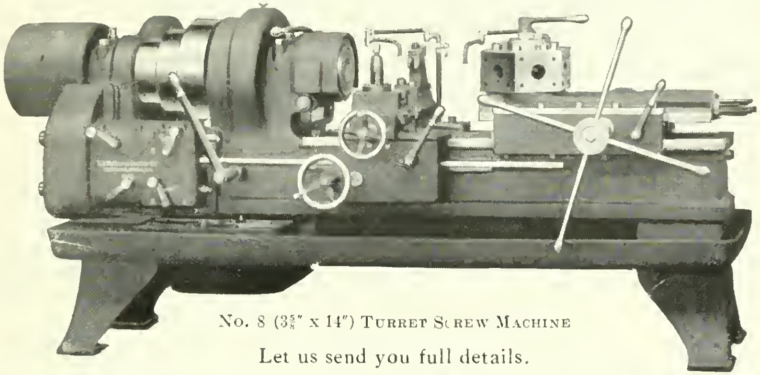

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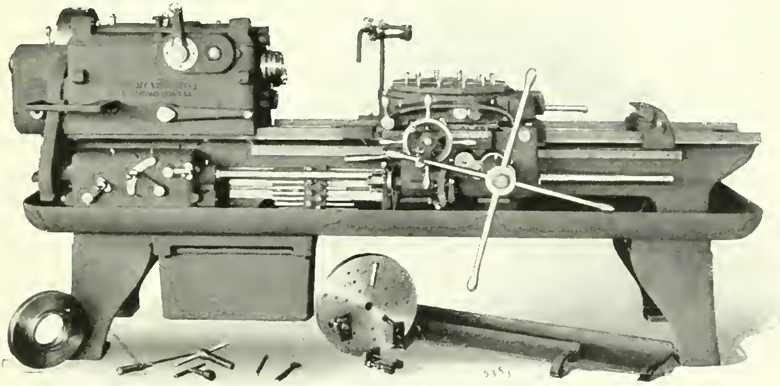

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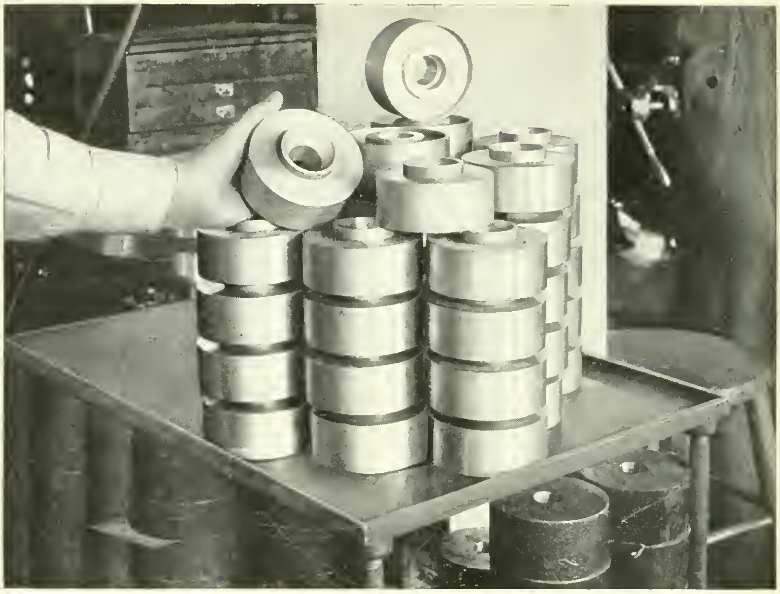

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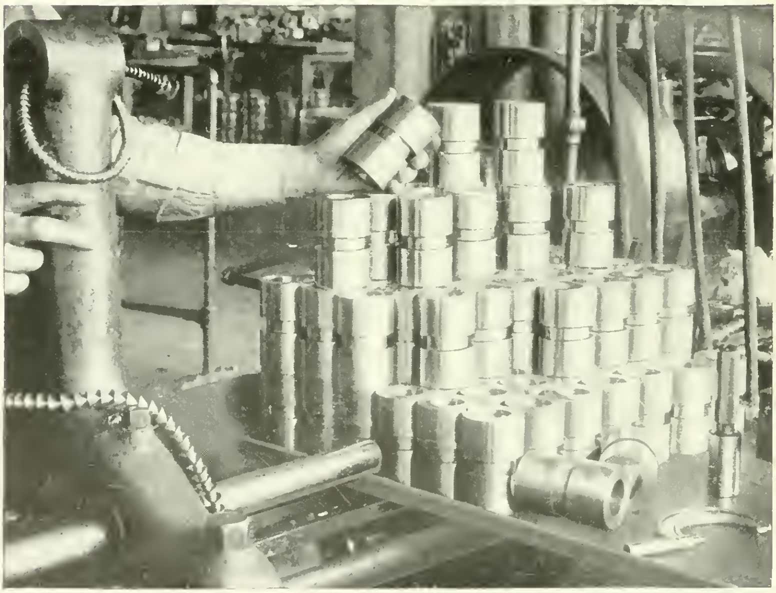

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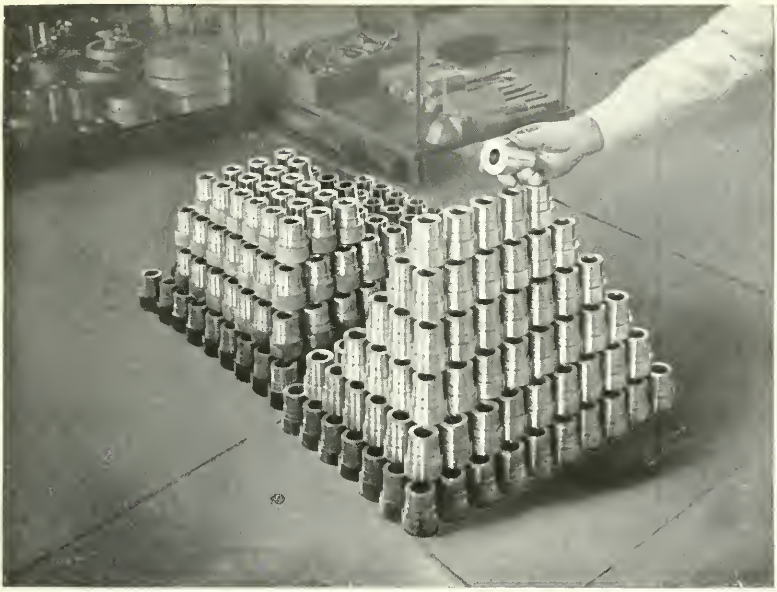

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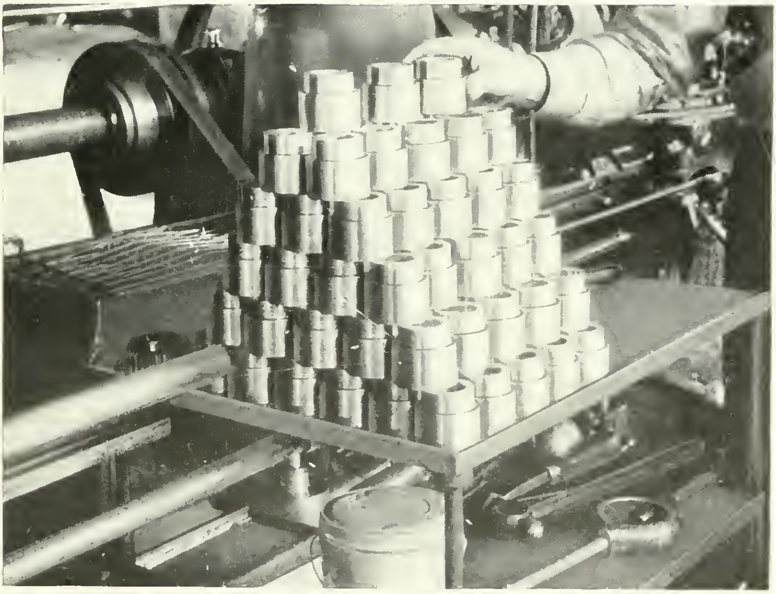

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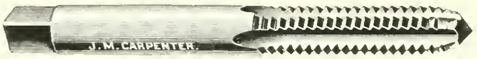
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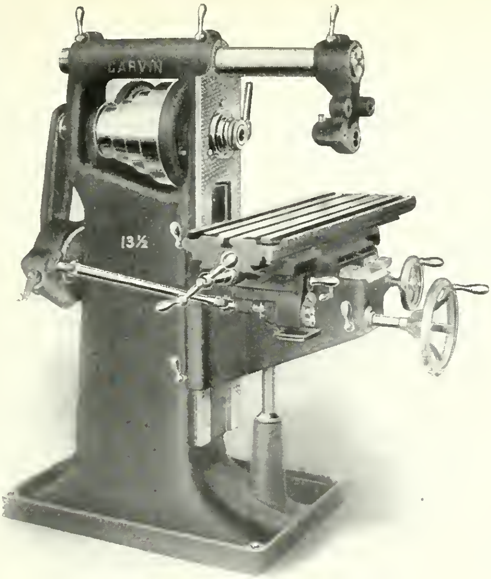

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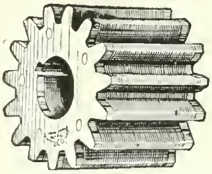

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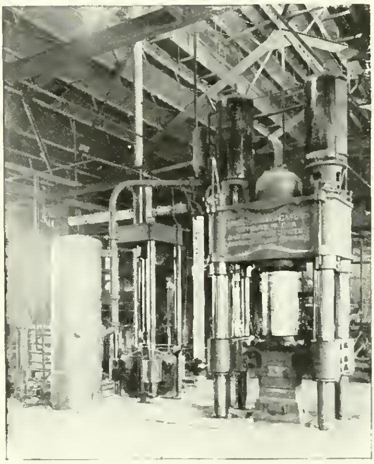

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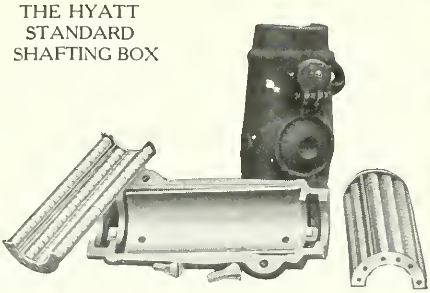

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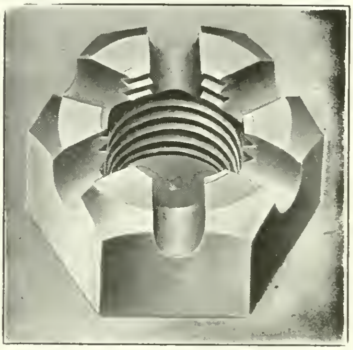

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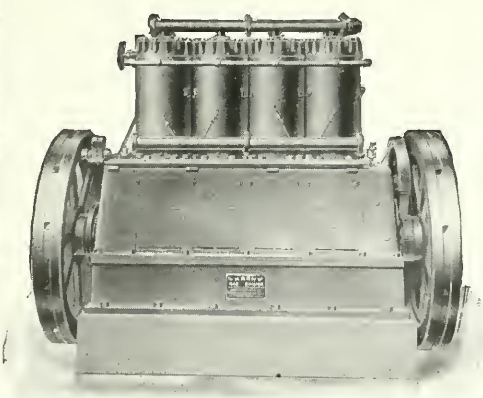

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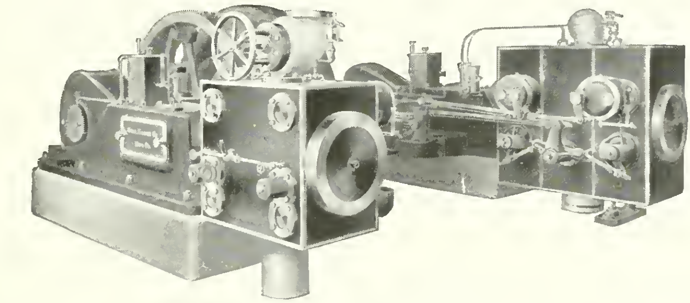

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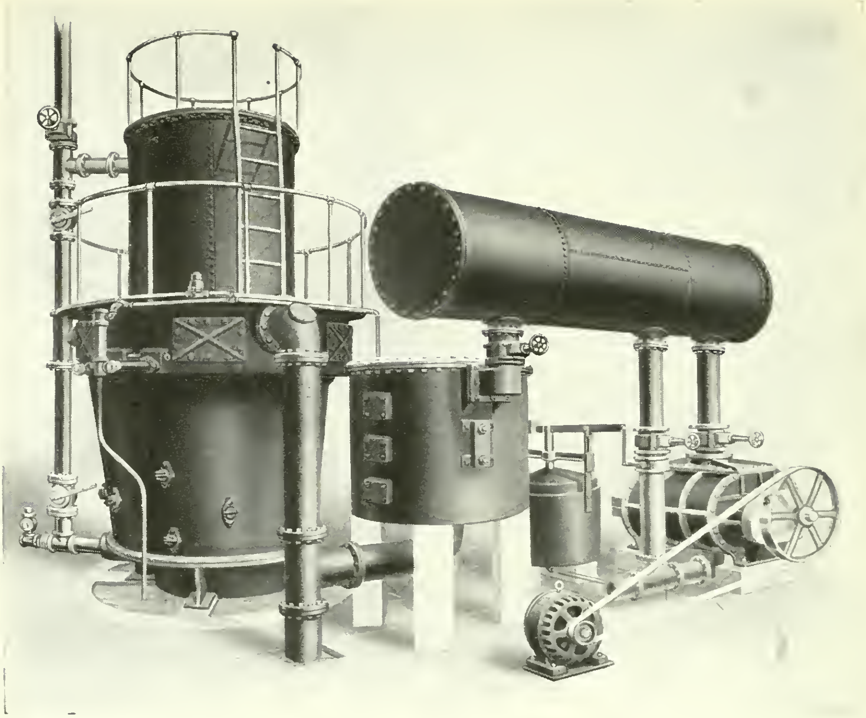

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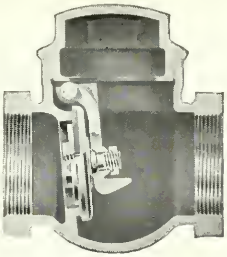

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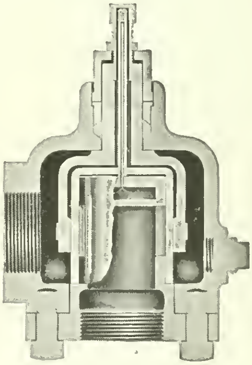

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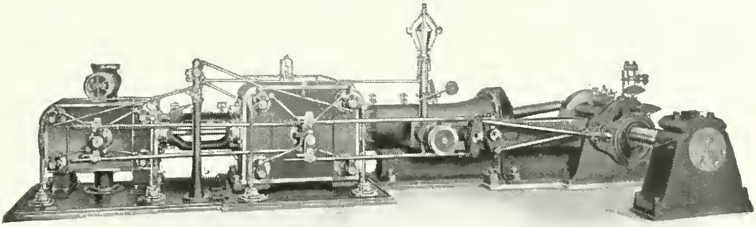

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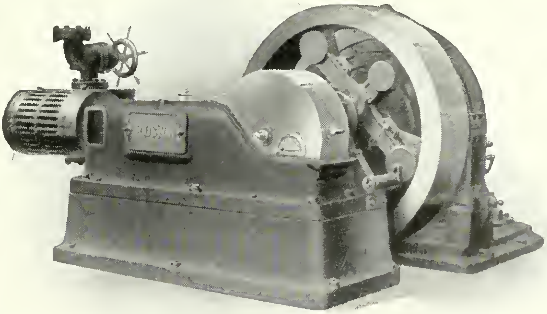

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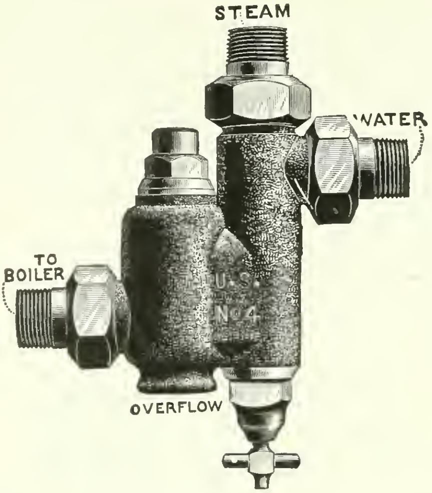

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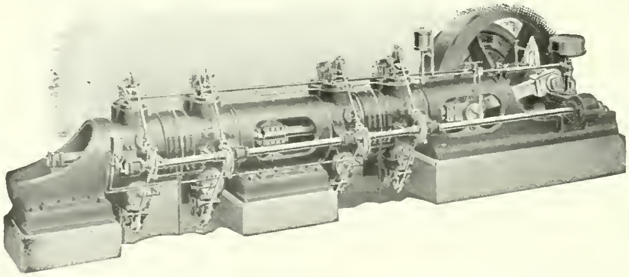

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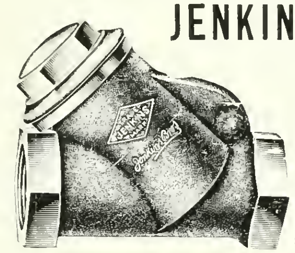

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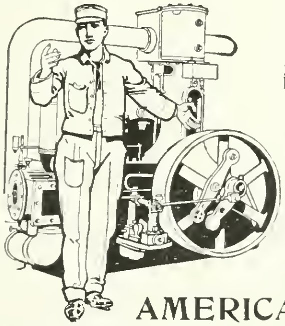

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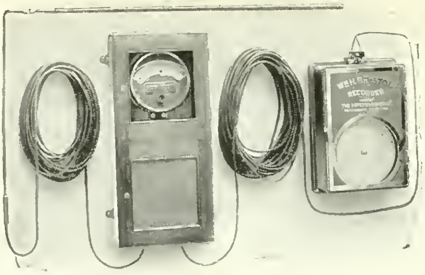

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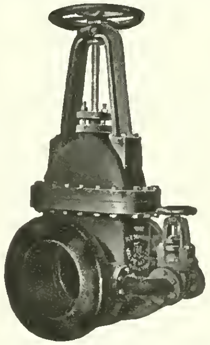

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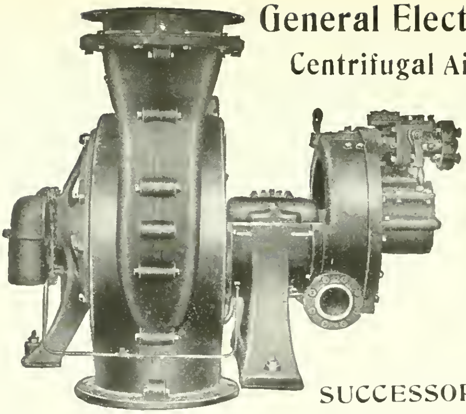

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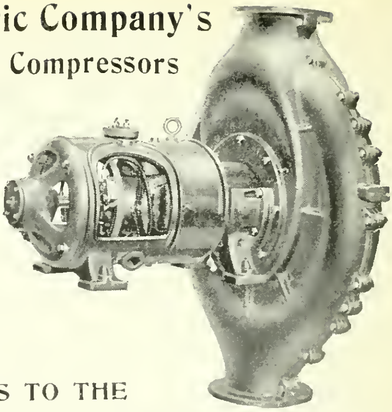

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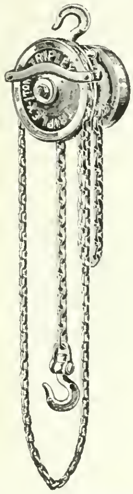

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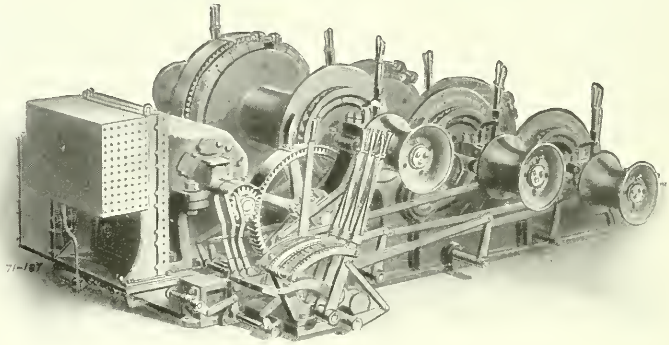

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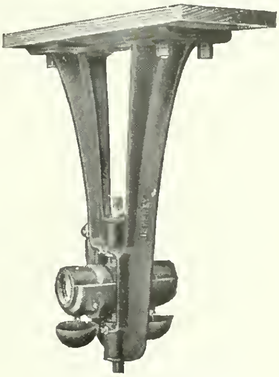

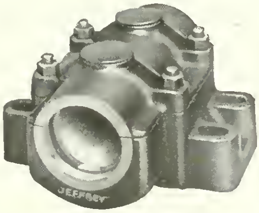

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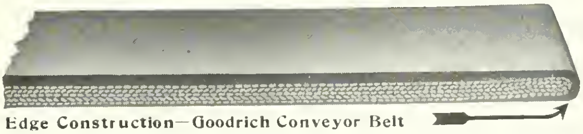

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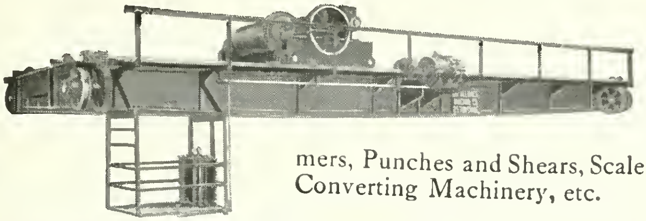

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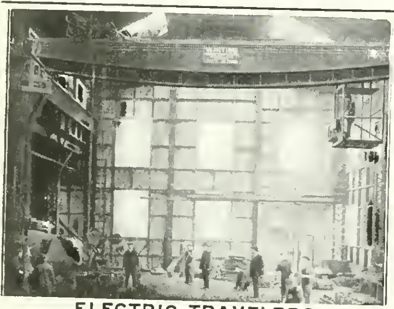

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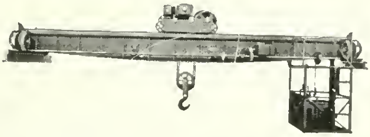

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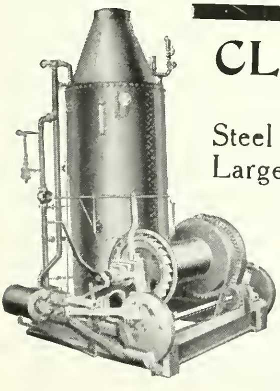

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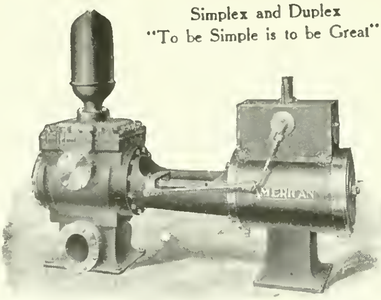

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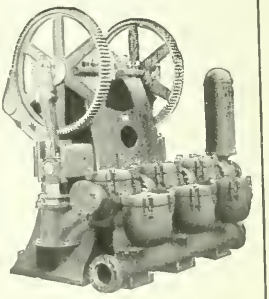

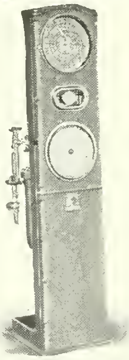

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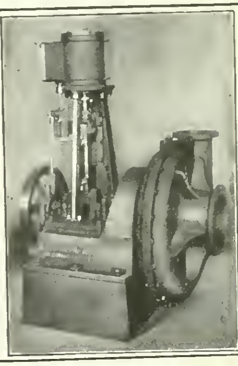

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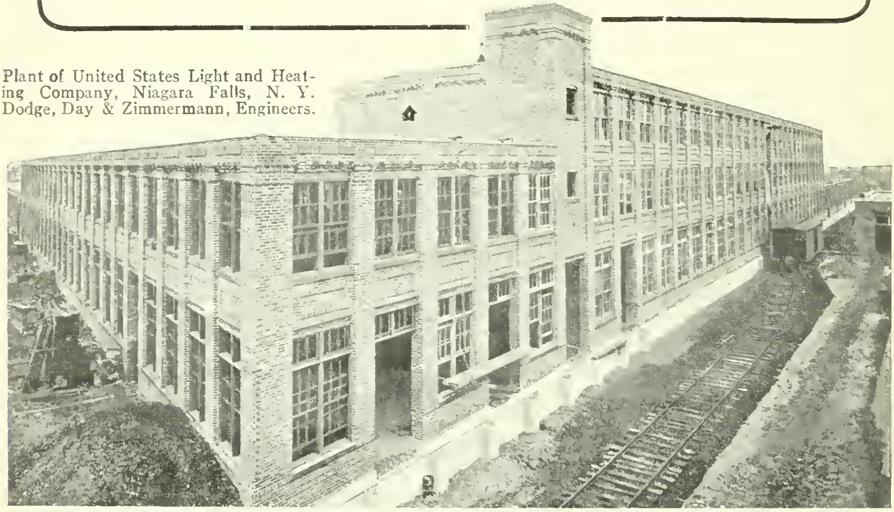
2. In Building Additions

If it has been found necessary to build additions, it is important to lay them out in such a way as to secure the most economical routing of materials and to comply in other particulars with the requirements of scientific management. These additions must lend themselves readily to still further expansion.

3. In Laying Out New Plants

The process of manufacture should be carefully studied in order to lay out a plant in which the highest efficiency can be attained and where departmental areas have been so closely estimated that there is no idle investment on account of unoccupied plant. A comprehensive scheme of expansion should be indicated in order to obviate expensive mistakes through building additions which do not accord with the latest practice as to physical facilities and administrative methods.



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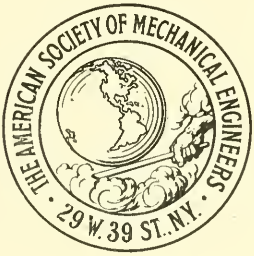

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THE
JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

JULY 1911

ANNUAL MEETING, NEW YORK, DECEMBER 5-8.

JULY 1911 VOL. 33 No. 7

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OF

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The Journal is published monthly by The American Society of Mechanical Engineers.
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The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 33 JULY 1911 NUMBER 7

RESOLUTIONS OF THANKS TO THE INSTITUTION OF MECHANICAL ENGINEERS

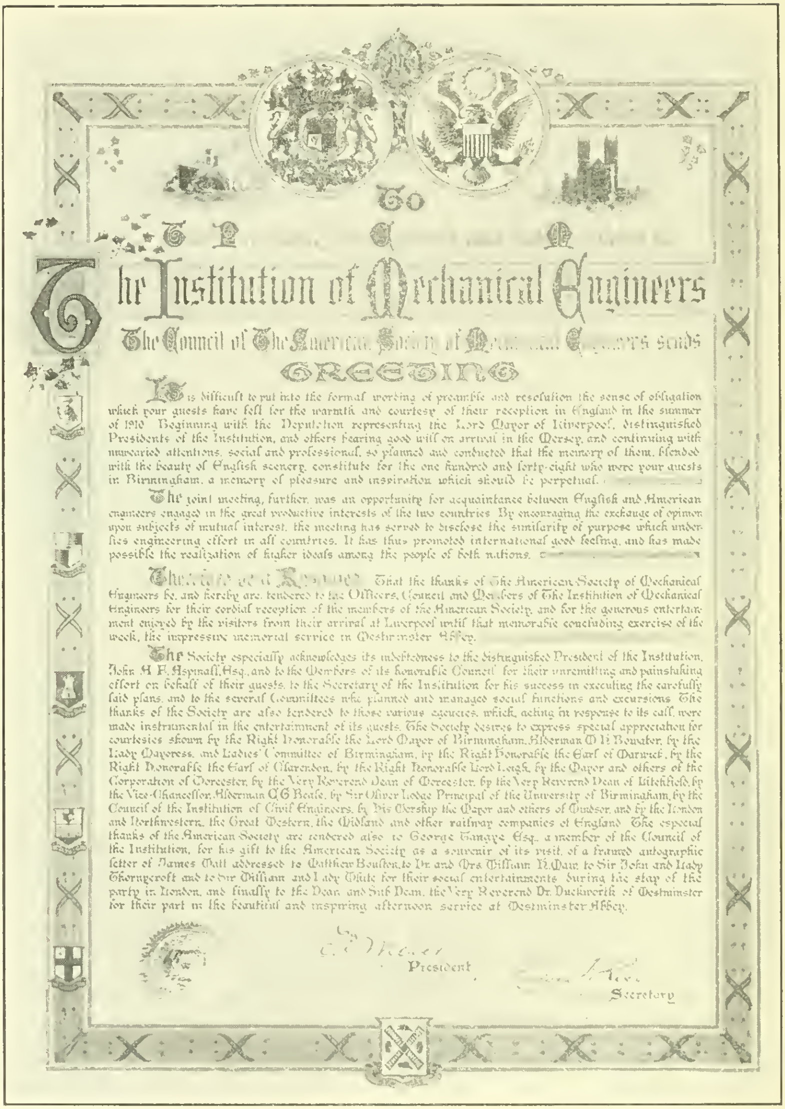
The members of the Society enjoying the hospitality so generously offered at the English meeting are sending to The Institution of Mechanical Engineers beautifully engrossed resolutions of thanks, a photograph of which appears on another page.

THE SPRING MEETING

The Spring Meeting was held at Pittsburg, Pa., May 30 to June 2, 1911, with an attendance of 307 members and 353 guests. Most of the social gatherings were held at the Hotel Schenley, where the registration headquarters were maintained, but the business meetings and professional sessions were held in the lecture hall of the Carnegie Institute and in the Carnegie Technical Schools.

This meeting was an unusually strong combination of pleasant social features, interesting technical excursions and valuable professional sessions. The papers were of unusual interest, and in spite of many other attractions the professional sessions were all well attended.

The local membership were very effectively organized into an executive committee, E. M. Herr, Chairman; with sub-committees on finance, George Mesta, Chairman; entertainment, J. M. Tate, Jr., Chairman; hotels, C. B. Albree, Chairman; printing and publicity, Morris Knowles, Chairman; and transportation, D. F. Crawford, Chairman. These committees contributed much to the success of the meeting by the painstaking manner in which they provided for the comfort and entertainment of the visiting members and guests.



To

The President, Council and Members of

The Institution of Mechanical Engineers

The Council of The American Society of Mechanical Engineers sends

GREETING

It is difficult to put into the formal wording of preamble and resolution the sense of obligation which your guests have felt for the warmth and courtesy of their reception in England in the summer of 1910. Beginning with the Deputation representing the Lord Mayor of Liverpool, distinguished Presidents of the Institution, and others bearing good will on arrival in the Mersey, and continuing with unwearied attentions, social and professional, so planned and conducted that the memory of them, blended with the beauty of English scenery, constitute for the one hundred and forty-eight who were your guests in Birmingham, a memory of pleasure and inspiration which should be perpetual.

The joint meeting, further, was an opportunity for acquaintance between English and American engineers engaged in the great productive interests of the two countries. By encouraging the exchange of opinion upon subjects of mutual interest, the meeting has served to disclose the similarity of purpose which underlies engineering effort in all countries. It has thus promoted international good feeling, and has made possible the realization of higher ideals among the people of both nations.

Therefore be it Resolved: That the thanks of The American Society of Mechanical Engineers be, and hereby are, tendered to the Officers, Council and Members of The Institution of Mechanical Engineers for their cordial reception of the members of the American Society, and for the generous entertainment enjoyed by the visitors from their arrival at Liverpool until that memorable concluding exercise of the week, the impressive memorial service in Westminster Abbey.

The Society especially acknowledges its indebtedness to the distinguished President of the Institution, John A. F. Aspinall, Esq., and to the Members of its honorable Council for their unremitting and painstaking effort on behalf of their guests, to the Secretary of the Institution for his success in executing the carefully laid plans, and to the several Committees who planned and managed social functions and excursions. The thanks of the Society are also tendered to those various agencies which, acting in response to its call, were made instrumental in the entertainment of its guests. The Society desires to express special appreciation for courtesies shown by the Right Honorable the Lord Mayor of Birmingham, Alderman W. H. Bowater, by the Lady Mayoress, and Ladies' Committee of Birmingham, by the Right Honorable the Earl of Warwick, by the Right Honorable the Earl of Clarendon, by the Right Honorable Lord Leigh, by the Mayor and others of the Corporation of Worcester, by the Very Reverend Dean of Worcester, by the Very Reverend Dean of Lichfield, by the Vice-Chancellor, Alderman C. G. Beale, by Sir Oliver Lodge, Principal of the University of Birmingham, by the Council of the Institution of Civil Engineers, by His Worship the Mayor and others of Windsor, and by the London and Northwestern, the Great Western, the Midland and other railway companies of England. The especial thanks of the American Society are tendered also to George Tangye, Esq., a member of the Council of the Institution, for his gift to the American Society as a souvenir of its visit, of a framed autographic letter of James Watt addressed to Matthew Boulton, to Dr. and Mrs. William H. Maw, to Sir John and Lady Thornycroft and to Sir William and Lady White for their social entertainments during the stay of the party in London, and finally to the Dean and Sub Dean, the Very Reverend Dr. Duckworth of Westminster for their part in the beautiful and inspiring afternoon service at Westminster Abbey.

President

Secretary

Resolution of Thanks to the Institution of Mechanical Engineers

Registration proceeded during the morning and afternoon of May 30, and in the evening an informal reunion was held by the Local Committee, which gave opportunity for the renewal of acquaintances and the making of new ones. A pleasant feature of the reunion was the presentation to President Meier of an engrossed testimonial of personal esteem and appreciation of his distinguished military and engineering services, by a group of friends in the Society on the occasion of his seventieth birthday. C. J. H. Woodbury made the presentation in the following words:

The flight of time is so noiseless that it requires anniversaries to mark its progress, and at a meeting of engineers in Boston a few weeks ago, it was remarked that you would have a notable anniversary on this occasion which ought to be recognized in a manner similar to that of the seventieth birthday of several of your associates and predecessors, and the matter was placed in the hands of a committee of your fellow-members from various parts of this country.

Your career has been indeed a notable one in its facility of doing many things and doing them well.

In the service of your country in both cavalry and artillery, you became a part of movements of national history. In the reorganization of the militia of your State, you became a force in the maintenance of law and order.

It is, however, in the greater victories of peace that we have come more closely in touch with your career as an engineer.

You have been connected with the great cotton industry in making improvements in baling the raw material, in mill construction, and also that of the textile machinery which produces the finished product.

In the great problem of transportation you have been connected with locomotive practice and railway management.

The functions of the engineer as an economist have been wrought by you yourself in the generation of steam and in the more radical innovations of the internal combustion engine.

But this recital of deeds well done is trite in comparison with that of the respectful tribute which we give to your sterling manhood which has endeared you to those with whom you have been associated.

Accept then, this engrossed testimonial briefly stating our felicitations; and this will be followed in due time by a folio containing the names of those taking part in this testimonial, and we ask you to give sittings to an artist whose portraiture will I trust be worthy of the subject.

In accepting the testimonial Colonel Meier replied as follows:

Dr. Woodbury and Friends, Members of The American Society Mechanical Engineers:

I receive at your hands this testimonial of friendship and esteem with feelings of deep gratitude and honest pride: gratitude that so many friends in our great Society feel so warmly towards me as to unite in this cordial congratulation; pride in the knowledge that my honest endeavor to do sound engineering work is appreciated by colleagues, who, as I see by the names of your committee, represent all sections of our country.

I have always believed and have acted on the conviction that the first question for an engineer is to determine what his duty is and then to do it with his whole heart; and that he who does his duty need not worry about his rights.

I have not always succeeded in my work but I have at least aimed high. I fully realize that in receiving the honors you bestow on me, I am acting as a representative of many colleagues whose good work has made success possible, and I accept them in the proud feeling that they are the spontaneous offerings of men in that noble profession to which the marvelous development of this Union in all the arts of peace is mainly due.

I feel that by your gracious act you impose on me the welcome duty to remain in harness for a decade or two more, or rather as long as I can be of service to engineers. Again with a full heart, I thank you and your associates.

The testimonial, a photograph of which is shown on the opposite page, reads as follows:

To Colonel Edward Daniel Meier:

The undersigned Committee of your fellow members of The American Society of Mechanical Engineers, on behalf of those associated with them, tender to you their cordial regards in commemoration of your seventieth birthday, in appreciation of your distinguished career in military service and in engineering, to which you have made many notable contributions, and in which you have established an honorable name.

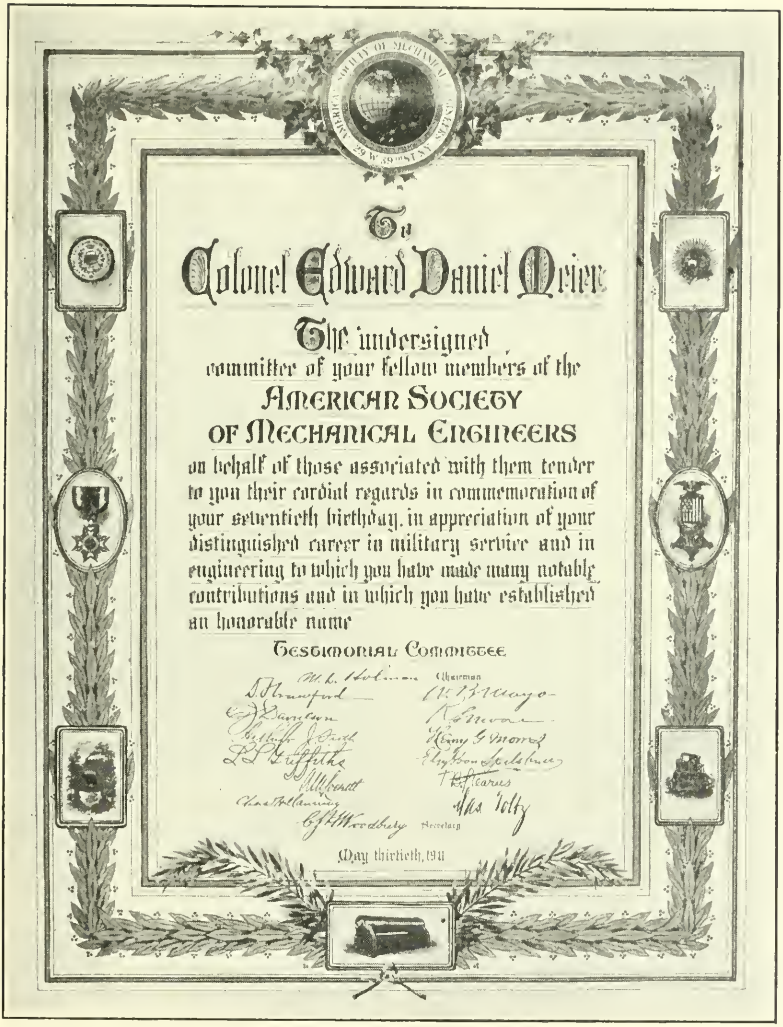
M. L. Holman, *Chairman*
C. J. H. Woodbury, *Secretary*

David F. Crawford
Charles J. Davidson
Arthur J. Frith
Leonard L. Griffiths
Andrew M. Lockett
Charles H. Manning

William Benson Mayo
R. S. Moore
Henry G. Morris
E. Gybbon Spilsbury
Thomas B. Stearns
Max Toltz

May 30, 1911.

On the opening day also, many members took the opportunity of visiting the exhibit of the Foundry and Machine Exhibition Company, originally provided for the convention of the American Foundrymen's Association during the previous week and held over for the benefit of the members of this Society.



To

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an honorable name

Testimonial Committee

M. L. Holman Chairman
D. Crawford
W. B. Mayo
Geo. J. Davison
R. S. Moore
Arthur J. Frith
Henry G. Morris
L. L. Griffiths
E. Gybbon Spilsbury
A. L. Abbott
T. R. Stearns
Chas. H. Manning
Max Toltz
C. J. H. Woodbury Secretary

May thirtieth, 1911

Testimonial Presented to Col. E. D. Meier

WEDNESDAY MORNING, JUNE 1—BUSINESS AND PROFESSIONAL SESSION

The meeting was called to order at ten o'clock by President Meier, the first business being the report of the Tellers of Election to Membership. The following elections to membership and promotions were announced by the President:

MEMBERS

Albert, Calvin Dodge, Ithaca, N. Y.
Almquist, Karl, New York,
Arnold, Anthony Brown, Boston, Mass.
Baquet, Camille, Jr., Williamsport, Pa.
Bayne, George Henry.
Berresford, Arthur W., Milwaukee, Wis.
Blair, William Richard, Webster Groves, Mo.
Bonnett, Louis Blake, Elizabeth, N. J.
Cole, Fred Baker, Boston, Mass.
Cross, Charles Norman, Palo Alto, Cal.
Dallis, Park Andrew, Atlanta, Ga.
Davis, Leon Keith, Providence, R. I.
D'Oller, William Livingston, Philadelphia, Pa.
Donnelly, James Alfred, New York.
Drew, Wilbert Shepard, Logan, Utah.
Ellis, Halcolm, Newark, N. J.
Ford, William Lucas, Boston, Mass.
Forgee, Frederick Angus, New York.
Forsburg, Henry A., Berkeley, Cal.
Francis, Isaac Hathaway, Jr., Philadelphia, Pa.
Gartley, Alonzo, Honolulu, Hawaii.
Gilbert, E. E., Schenectady, N. Y.
Going, Charles Buxton, New York.
Gordon, Albert Anderson, Jr., Worcester, Mass.
Graham, William Harvey, Sydney Mines, B. C.
Greenwall, Walter L., Milwaukee, Wis.
Hall, Harris Forster, Chicago, Ill.
Hall, Walter Atwood, Swampscott, Mass.
Hammond, Myram Hance, Hudson, N. Y.
Hawthorne, Primm R., Battle Creek, Mich.
Hobbs, Franklin Warren, Boston, Mass.
Houchin, Ernest A., Brooklyn, N. Y.
Howell, Sylvester S., Chicago, Ill.
Jamieson, Charles Clark, Hoosick Falls, N. Y.
Johnson, John Samuel Adolphus, Blacksburg, Va.
Johnson, Raymond D., Niagara Falls, N. Y.
Johnston, William Atkinson, Boston, Mass.
Kendrick, J. W., Chicago, Ill.
Lamar, Philip Rucker, Augusta, Ga.
Law, Frank E., New York.
Leisen, Theodore Alfred, Louisville, Ky.
Lewis, Frederick Humphreville, Birmingham, Ala.
Lindberg, Fritz Albin, Chicago, Ill.
Longacre, Fredrieck van Duzer, New York.
Maguire, Jeremiah De Smet, New York.
Morse, Arthur Holmes, Cincinnati, O.
Nailler, Raymond Frederick, Elyria, O.
Newman, Martin Freeze, Pittsburg, Pa.
Norton, Arthur Edwin, Cambridge, Mass.
Olivenbaum, John Emmanuel, Cleveland, O.
Parrock, H. P., Buffalo, N. Y.
Perkins, Julius A., New York.
Reid, Joseph Snively, Belmont, N. Y.
Riege, Rudolph, Stamford, Conn.
Rollins, William Benjamin, Kansas City, Mo.
Rowell, Henry K., Waltham, Mass.
Sankey, Capt. H. Riall, London, England.
Scott, Charles Felton, Pittsburg, Pa.
Sessions, Edson O., Chicago, Ill.
Smith, Albert Samuel, Boston, Mass.
Stanley, Frank A., Stapleton, S. I., N. Y.
Stoddard, Elgin, San Francisco, Cal.
Straub, C. Lee, Port Richmond, N. Y.
Sulzer, George H., Arlington, N. J.
Sweet, Ernest E., Detroit, Mich.
Thiemer, William H., Cleveland, O.
Thorkelson, Halsten Joseph, Madison, Wis.
Veness, Alfred E., Bridgeport, Conn.
Vosbury, W. DeWitt, Philadelphia, Pa.
Whitney, Clarence Edgar, Hartford, Conn.
Whitney, William S., Lawrence, Mass.
Wilkie, Donald Cook, Seremban, Federated Malay States.
Woodman, George A., Chicago, Ill.

PROMOTION TO MEMBERS

Alexander, Ludwell Brooke, New York.
Barstow, Francis L., Mittineague, Mass.
Brooks, J. Ansel, Providence, R. I.
Cluett, Sanford L., Hoosick Falls, N. Y.
Cole, Arthur Williams, Lafayette, Ind.
DeCazenove, Louis Albert, Jr., Wilmington, Del.
Dixon, Charles Francis, New York.
Fox, R. E., Jr., New York.
Gay, Harry, Boston, Mass.
Kenney, Lewis Hobart, Philadelphia, Pa.
Klein, Arthur Warner, Bethlehem, Pa.
Matthews, Fred. Elwood, New York.

PROMOTION TO MEMBERS—CONTINUED

Rautenstrauch, Walter, New York.
Ray, David H., New York.
Ruckes, Joseph John, Jr., Chicago, Ill.
Rutherford, Eugene W., Brooklyn, N. Y.
Sheperdson, John William, Johnstown, Pa.
Van Valkenburgh, Ralph D., Scranton, Pa.
White, John Culbertson, Madison, Wis.
Wyer, Samuel S., Columbus, O.
Yarnall, Daniel Robert, Philadelphia, Pa.
York, Robert, Memphis, Tenn.

ASSOCIATES

Boblett, Kinderman M., Toledo, O.
Hunt, Samuel J., St. Louis, Mo.
Israel, Charles Henry, Baltimore, Md.
Klockars, Charles Oscar, Newark, N. J.
McIntosh, Walter S., West Roxbury, Mass.

JUNIORS

Andrei, Camillo, Milan, Italy.
Arter, Wilbur D., Mt. Vernon, N. Y.
Bausch, Carl L., Rochester, N. Y.
Briggs, Leroy Edmund, Boston, Mass.
Buck, Lucien, Canton, N. C.
Burroughs, Joseph Howell, Jr., Westmont, Pa.
Cariss, Carington Carysfort, London, Ontario, Canada.
Clayton, Jean Paul, Urbana, Ill.
Cullen, William Vincent, Buffalo, N. Y.
Dennis, Basil Wrenn, Muskogee, Okla.
Douglas, Walter Cooley, New York.
Downes, Nate Worswic, Kansas City, Mo.
Dunsford, Jan R., Alliance, O.
Fabens, Andrew Lawrie, New Kensington, Pa.
Finch, Ellis Jerome, New York.
Flickinger, Harrison William, Clairton, Pa.
Gamble, William John, Buffalo, N. Y.
Garrahan, Frederick Benton, West New Brighton, N. Y.
Gates, John George, Port Chester, N. Y.
Hall, Carl Albe, Concord, N. H.
Hartwell, Arthur Edward, Houston, Tex.
Hatman, Julius G., Kansas City, Kan.
Hider, George Turner, Greenloch, N. J.
Honywill, Albert William, Jr., New Haven, Conn.
Howard, Henry Sherwin, San Francisco, Cal.
Hubbard, Carleton Waterbury, Greenwich, Conn.
Humes, W. Sharon, Chicago, Ill.
Humphrey, Charles Scranton, South Bethlehem, Pa.
Knox, Clarence M., Hartford, Conn.
Koester, Herman, Waterbury, Conn.
Lindquist, Eric Adolf, Pottstown, Pa.
Loeb, Leo, Troy, N. Y.
Lydecker, Kenneth, New York.
McCollum, Caleb Addison, Wilkinsburg, Pa.
Magrath, Charles Bolton, Boston, Mass.
Mann, Harvey Blaine, Philadelphia, Pa.
Marshall, John Henderson, Diamon City, Alta., Canada.
Meyer ,Erwin Charles, New York.
Milner, Bert Branson, Philadelphia, Pa.
Mullhaupt, Alfred, Jr., St. Marys, Pa.
Munson, Stanley, South Bend, Ind.
Murphy, Thomas Robert Hoysted, New York.
Murphy, William T., Providence, R. I.
Nickerson, John Winslow, Saylesville, R. I.
Packard, Horace Nelson, Milwaukee, Wis.
Prout, Henry Byrd, New York.
Randall, John Arthur, Brooklyn, N. Y.
Rea, James Childs, Pittsburg, Pa.
Rentschler, Gordon Sohn, Hamilton, Ohio.
Rowe, Don Ray, Dayton, O.
Ruddy, William, Hoosick Falls, N. Y.
Sawyer, Luke Eugene, Brighton, Mass.
Schiefer, Fred. William, Buffalo, N. Y.
Stix, Lawrence Cullman, Cudahy, Wis.
Tallmadge, Webster, Brooklyn, N. Y.
Towne, Willis Lyman, Southbridge, Mass.
Truette, Arthur Pierce, Brookline, Mass.
Wentworth, Reginald Andrew, Southbridge, Mass.
Zimmermann, William Frederick, Newark, N. J.

The following amendment to C 21 of the Constitution was proposed by the Committee on Meetings in New York, which will be acted upon later in the usual manner:

Members of all grades residing in New York and vicinity and represented by the Committee on Meetings in New York City, should have the privilege and authority by majority vote of such membership to increase their annual dues by the sum of $3.00, such increase to be applied to financing such entertainment features of the Annual Meetings in New York City and its own local meetings as their Committee on Meetings in New York City may elect.

Reports were received from the Committee on Identification of Power House Piping and from the Committee on Standard Flanges. The former was published in The Journal for June 1911, and the latter was distributed in pamphlet form. No action was taken on either of these reports, pending the receipt of discussion, which may be received up to August 1.

Announcement was made that the Society had been invited to meet in 1912 at St. Paul, Cleveland and Baltimore. The claims of each city to consideration were set forth and the members present were asked to indicate to the Council their preferences. Following the receipt of these expressions the Council carefully considered the matter and finally decided that the Spring Meeting of 1912 should be held in Cleveland. This city presents many points of general and industrial interest, and arrangements for the meeting will be in charge of a large and active organization of engineers.

The remainder of the session was devoted to the presentation and discussion of three papers on various phases of the mechanical engineering of cement manufacture. The first of these papers was upon Some Problems of the Cement Industry, by W. S. Landis, of South Bethlehem, Pa., outlining the directions in which improvements in processes must take place and calling attention to some of the ways in which better economy is being obtained abroad. The author stated that the development of the cement industry was dependent on better engineering, and he invited the attention of mechanical engineers to the unsolved problems.

W. H. Mason, of Stewartsville, N. J., then presented his paper on The Edison Roll Crushers, in which were set forth the theories on which Mr. Edison based his development of this apparatus for reducing the cost of quarrying and crushing stone. The machinery was described in detail and data were given regarding horsepower required, cost of maintenance, and time lost due to repairs over a period of years.

L. L. Griffiths then followed with his paper on Power and Heat Distribution in Cement Mills, in which he gave data regarding five different types of power equipment, together with unit costs and outputs of the various types. These papers were discussed by F. B. Gilbreth, R. K. Meade, W. R. Dunn, H. Struckmann, C. J. Reilly, G. P. Hemstreet, F. L. Schwenk, H. E. Brown, W. B. Ruggles, W. M. Kinney, and Paul C. Van Zandt.

At the close of this session it was announced that a committee was being formed, with the coöperation of the Association of American

Portland Cement Manufacturers, to conduct investigations, secure papers and reports and to hold meetings on questions concerning the mechanical engineering features of the cement industry. Considerable interest was shown in this movement and it is believed that great progress may be made through the efforts of such a committee.

WEDNESDAY AFTERNOON

Immediately following the adjournment of the morning session, a special train conveyed the members and guests from the Union Depot to the works of the Universal Portland Cement Company, at Universal, Pa., where guides conducted the party through the plant, which is producing 12,000 barrels of cement per day, using slag from the Bessemer furnaces of the Carnegie Steel Company, and electric power generated from blast furnace gas at the Carrie furnaces of the Carnegie Steel Company. On the return a stop was made at East Pittsburg, where the party was shown through the works of the Westinghouse Electric & Manufacturing Company and of the Westinghouse Machine Company adjoining. Opportunity was given to inspect the large electric locomotives being built for the Pennsylvania Railroad, as well as steam turbines and gas engines in various stages of construction. Owing to the short time available for this excursion, luncheon was provided on the train.

In the evening two well-attended sessions were held simultaneously. One of these, the Machine Shop Session, was held in the lecture hall of Carnegie Institute, while the Gas Power Section met in the Carnegie Technical School.

MACHINE SHOP SESSION

The first three papers, constituting a symposium on the subject of the production of small interchangeable parts, were presented and discussed together.

John Calder, of Ilion, New York, under the title The Assembly of Small Interchangeable Parts, treated the subject broadly, with special reference to the methods used by the Remington Typewriter Company, calling attention to the importance of proper design as affecting the economical production of the parts, and outlining the methods used in preparing for the production of each part, in fixing the rate, and in dividing the labor to the best advantage.

The second paper, The Process of Assembling a Small and Intricate Machine, by Halcolm Ellis, was presented in the absence of the author by Nathan W. Perkins, Jr., of Newark, N. J. This paper described the methods used in designing an intricate machine so that it might be assembled quickly and economically, and developed quite fully the methods employed in gathering together the large number of parts of which it is composed.

Another phase of the same subject was treated by F. P. Cox, of West Lynn, Mass., who discussed in his paper, Quantity Manufacture of Small Parts, the ways in which an organization for this purpose differs from that in the usual manufacturing plant. Discussion on these papers was participated in by Hugo Diemer, E. Puchta, J. P. Johnston, W. J. Kaup and A. C. Jackson.

A. L. DeLeeuw, Cincinnati, Ohio, in a paper on Milling Cutters and their Efficiency, outlined briefly a large number of experiments made to determine the most efficient forms of milling cutters. The paper was discussed by W. S. Huson, John Parker and A. F. Murray.

GAS POWER SECTION

A topical discussion on large blast-furnace gas-power plants was opened by A. E. Maccoun, superintendent of furnaces at the Edgar Thomson Works of the Carnegie Steel Company, and a great deal of valuable material regarding gas engine design and operating difficulties was brought out. The discussion was continued by R. H. Stevens, mechanical engineer, Homestead Steel Works; A. N. Diehl, superintendent of furnaces, Duquesne Steel Works; A. L. Hoerr, steam and hydraulic engineer, National Tube Company; H. J. Freyn, assistant engineer of construction, Illinois Steel Company, and others.

This was followed by a report on the recent work of the United States Bureau of Mines, prepared by S. B. Flagg and C. D. Smith, engineers connected with the Fuel Testing Station at Pittsburg, and presented by the latter. This paper related principally to the recent work in gas producers, and the experiments in briquetting low-grade fuels for various uses.

On Wednesday morning the ladies were conducted through the Margaret Morrison Carnegie School for Women, connected with the Carnegie Technical Schools, after which they proceeded through Schenley Park to the Pittsburg Golf Club, where luncheon was served.

In the afternoon, the Ladies' Committee gave a tea for the visiting ladies at the Hotel Schenley, and in the evening a visit was made to the International Art Exhibit at the Carnegie Institute, adjacent to the hotel.

THURSDAY MORNING—MISCELLANEOUS SESSION

At the session on Thursday morning, four papers on miscellaneous subjects were presented, and one was read by title. R. T. Stewart, of Pittsburg, presented in connection with his paper Stresses in Tubes, the results of a very elaborate investigation which showed that the stresses in the wall of a tube exposed to external fluid pressure are of the same character as those in a column having ends fixed in direction. In connection with the presentation of this paper, Professor Stewart contributed to the Library of the Society a large volume containing detailed records of tests on tubes extending over a number of years. A unanimous vote of thanks was tendered to Professor Stewart for his gift.

In the absence of the author, Perry Barker presented a paper on The Purchase of Coal, by D. T. Randall, in which attention was called to the possibilities of greater fuel economy through the purchase of coal suited to the particular use for which it is intended, under detailed specifications and guaranteed analyses. Discussion on this paper was offered by R. C. Carpenter, W. F. M. Goss, E. D. Meier, C. W. Rice and C. W. Baker.

The next paper, Energy and Pressure Drop in Compound Steam Turbines, by F. E. Cardullo, of Durham, N. H., proposed an empirical formula and a graphical method for determining the power development in each stage of a turbine. Discussion was offered by W. H. Herschel, C. H. Peabody and W. D. Ennis.

The paper by L. S. Marks, The Pressure-Temperature Relations of Saturated Steam, not being adapted for discussion in open meeting was read by title only, publication having been made in The Journal for May 1911.

G. C. Anthony, of Tufts College, Mass., presented the last paper of the session on A Pressure Recording Indicator for Punching Machinery, a summary of a large number of experiments made to determine the power required for punching plates of various materials with punches of different types. This was accomplished by the use of an ordinary steam-engine indicator operated by hydraulic pressure transmitted from a specially constructed punching die. R. C. Carpenter and Julian Kennedy discussed the paper.

THURSDAY AFTERNOON AND EVENING

After an early luncheon, those who desired to visit the works of the National Tube Company at McKeesport took special cars from the hotel and proceeded directly to the works. At the same time the remainder of the members and ladies started on an excursion up the Monongahela River by special boat, stopping on the return trip at McKeesport for the party which had meanwhile completed its inspection of the tube plant. Music and refreshments were provided on the boat, and the trip proved most enjoyable in every way, giving an opportunity also to view many of Pittsburg's most notable industries.

Thursday evening was devoted to a reception by the local membership to the visiting members and guests at the Hotel Schenley. A number of persons prominent in social and business circles in Pittsburg had been invited to attend, and the evening was greatly enjoyed by all. There was dancing throughout the evening and supper was served from 10:30 to 12:30.

FRIDAY MORNING—STEEL WORKS SESSION

At the session on Friday morning, some of the recent developments in steel works practice were brought up and discussed. Methods of supplying air to blast furnaces were covered by the paper, Commercial Application of the Turbine Turbo-Compressor, by R. H. Rice, of West Lynn, Mass., and another on Reciprocating Blast Furnace Blowing Engines, by W. Trinks, of Pittsburg. These papers were discussed together by J. E. Johnson, Jr., C. J. Bacon, Julian Kennedy, F. E. Cardullo, H. J. Freyn and Joseph Morgan.

The Society was privileged to have another new development presented by Barthold Gerdau, of Düsseldorf, Germany, who came to this country for the purpose of presenting his paper on Power Forging, with Special Reference to Steam-Hydraulic Forging Presses. Discussion was offered by J. I. Rogers and W. E. Hall.

FRIDAY AFTERNOON

Two inspection trips were available for Friday afternoon and the parties formed proceeded, one to the works of the Carnegie Steel Company at Duquesne by special cars, and the other to the works of the Mesta Machine Company at West Homestead by special cars and train from the Union Depot. At the steel works opportunity was given to inspect every stage of the manufacture of steel, from the unloading of the ore to the shipping of the finished material. Notable features were the freezing process for drying air supplied to the blast furnaces, and blowing engines operated by blast furnace gas.

At the Mesta Machine Company's works the party saw in process of erection a large four-stage air compressor, a twin rolling mill engine of 20,000 horsepower, a large gas engine, and a motor-driven shear capable of cutting a bar of cold steel 7 inches square. In the foundry, gear molding machines were in operation, and a heat of vanadium steel was poured, while in the forge shop steam-hydraulic forging presses were seen in operation. After luncheon had been served, the party returned to Union Depot by special train.

FRIDAY EVENING—SMOKER

The Spring Meeting was enjoyably concluded on Friday evening with a smoker and entertainment given to The American Society of Mechanical Engineers and guests by the Engineers Society of Western Pennsylvania, in the rooms of the Union Club, in the Frick Building. Brief speeches were made by E. M. Herr, Elmer K. Hiles, E. D. Meier, and Calvin W. Rice. George H. Neilson, of Pittsburg, delivered a very amusing address under the title, A Near History of Crucible Steel. Throughout the evening entertainment and refreshments were most generously furnished, and a spirit of good fellowship prevailed. This smoker formed a most pleasing climax to a very successful meeting.

The ladies were entertained throughout the day beginning with a trip through the parks and residential parts of the city in motor cars, after which the party inspected the works of the H. J. Heinz Company, where the officials entertained at luncheon. After leaving the works, the party motored to the Allegheny County Club at Sewickley, sixteen miles below Pittsburg on the Ohio River, where tea was served.

During the entire meeting the Ladies' Committee, Mrs. Chester B. Albree, Chairman, provided most hospitably for the pleasure of the visiting ladies, and in many other ways added greatly to the social features of the convention.

At the closing session on Friday morning, the following resolution was adopted by rising vote, in order to express to all concerned the appreciation of the visiting members for the elaborate preparations made for their convenience and pleasure by the local members, companies and institutions and for the cordial hospitality displayed on every side:

Whereas, The American Society of Mechanical Engineers, assembled in convention May 30 to June 2, 1911, at Pittsburg, Pa., has received a most cordial and spontaneous welcome from the members and friends of the Society in Pittsburg and vicinity; and has had the splendid coöperation and support of the local committee, through their tireless efforts on behalf of the Society, and their faultless preparation for the meeting, without which a convention of so marked a degree of excellence would have been impossible; and

Whereas, the visiting members and guests have been the recipients of the delightful entertainment bountifully provided, and have had the opportunity to view many of the industrial wonders and other notable attractions of this remarkable center;

Be it Resolved: That on behalf of the Society and of the visiting members and guests, a vote of thanks be extended to all who have participated in these substantial evidences of friendship and good-will, with the assurance that such a formal resolution is but a poor and outward symbol of the deep sense of gratitude which each visitor personally feels; further, that the Secretary be instructed to extend the thanks and appreciation of the Society, by written letter, to the local Executive Committee, the Ladies' Committee, and the other local committees; to the Foundry and Machine Exhibition Company, the Universal Portland Cement Company, the Westinghouse Companies, the National Tube Company, the Mesta Machine Company, the Carnegie Steel Company, and other organizations which have opened wide their doors or provided entertainment; to the educational and art institutions and clubs of the city, which the guests have taken great pleasure in visiting; to the Engineers' Society of Western Pennsylvania for their hospitable entertainment; and to Dr. Barthold Gerdau, who came from abroad to present his important paper.

MEETINGS OF THE SOCIETY

PHILADELPHIA MEETING, JUNE 3

A meeting of the Society was held in Philadelphia on June 3, at which the subject of Fuel Testing, presented at the meeting in that city on April 22, was continued. S. B. Flagg read a paper on the work of the United States Fuel Testing Bureau, in which, in addition to outlining the work on fuel testing and the testing of furnaces for proper combustion of the fuels, he showed slides and explained the work of prevention of mine explosions and the training of rescue parties. The paper was discussed by Messrs. J. C. Parker, James Christie, J. E. Gibson, C. A. Blatchley, Schwaab, Ray and Kriesinger.

ST. LOUIS MEETING, JUNE 7

Engineers of all branches of the profession, to the number of 220, assembled at dinner in the large dining room of the Mercantile

Club, St. Louis, on June 7, the arrangements for the occasion being in charge of the Engineers Club of St. Louis. At the conclusion of the dinner J. D. von Maur, President of the Engineers Club, explained, in his capacity of toastmaster, how the five societies, the American Society of Civil Engineers, the American Institute of Electrical Engineers, The American Society of Mechanical Engineers, the American Society of Engineering Contractors, and the Engineers Club, had got together and held a number of joint professional meetings, each under the auspices of one of these organizations, that all had found pleasure and profit in the discussions and that the social features had created better understandings and professional acquaintances which had generally ripened into friendship.

M. L. Holman, Past-President of The American Society of Mechanical Engineers and of the Engineers Club, was then introduced and told humorously of many personal reminiscences of early engineering in St. Louis, including the development of the water works and the building of the great Eads Bridge. In conclusion, he urged close association among all engineers.

E. D. Meier, President of The American Society of Mechanical Engineers, who followed Mr. Holman, congratulated the Engineers Club on its success in bringing engineers of all branches together. He explained how various societies were formed in the past in the belief that three or four great national bodies could divide the profession according to natural cleavage, and how it had now become apparent that perhaps a hundred or more branches of engineering must be recognized, although the professional needs of these could be satisfied by existing societies, delegating experts in each such branch to look after its interests, and possibly forming sections where the importance of the subject required it. This, he said, would at the same time make the administrative activities of the national body available for all these branches and recognize the advantages of social gatherings at conventions in familiarizing engineers with the work and capacity of others in the same or correlated lines, and would finally raise the profession in the social recognition of the American people to the high position to which it is entitled. He compared the scepticism of the community less than forty years ago regarding the St. Louis bridge with the readiness with which much greater and more hazardous works of engineering are today accepted as possible.

C. M. Woodward, Past-President of the Engineers Club and founder of the first manual training school of the country in St. Louis, followed with a happy speech, replete with personal reminiscences, expressing his rejoicing over the fact that whereas he had only taught engineering, many present who had graduated from his training had done things. He related also how he with his students rode on the first of the fourteen locomotives assigned to test the Eads Bridge and how the engineer was so agitated at the supposed danger of the trip that he reversed his engine at the signal to go ahead.

Col. Ed. Devoy followed with a humorous account of his own trepidation over hauling a three-and-a-half ton block of coal over the bridge to take part in the procession. He urged engineers to stand together and make their influence felt at the very inception of public works, thus preventing them from becoming the playthings of politicians who did not understand their merits.

The enthusiasm in the new-found sense of comradeship among engineers of all branches was proof that this get-together movement fills a genuine need and will spread country wide to the benefit of the profession. The plan of a simple dinner followed by a free discussion of the good of the order was so successful that it may be urgently commended to members of the Society in other engineering centers.

AN EFFORT TOWARD COÖPERATION

On June 15, the President of the Society, Colonel Meier, invited several members to a luncheon at the Machinery Club to meet Capt. A. M. Hunt, chairman of the Committee on Meetings of this Society in San Francisco, and prominent also in the work of other engineering societies. Those invited were A. C. Humphreys, Charles W. Baker, E. G. Spilsbury, W. M. McFarland, H. G. Stott and Calvin W. Rice.

A topic discussed was one which The American Society of Mechanical Engineers has been specially active in promoting, through meetings with other societies in different cities, that of the getting together of engineers in different fields for coöperation and the general advancement of the profession as a whole. Prominent among these efforts have been the meetings at Boston at one of which eight presidents and the representatives of many organizations were present and the recent meeting in St. Louis noticed elsewhere. The work of Captain Hunt in bringing together, as he has, engineers on the Pacific slope irrespective of their society affiliations, was most highly commended.

From the composition of the party called together for this occasion it is evident that each is representative of the spirit of coöperation through association with various engineering societies and the belief was expressed that definite plans which were discussed would serve as a means of promoting some general meetings to which the members of all engineering societies would be invited.

STUDENT BRANCHES

MISSOURI UNIVERSITY

The Missouri University Student Branch held the concluding meeting of its season on May 22, the Freshmen and Sophomore classes of the University being invited guests. Short talks on subjects of interest to the membership were given by Prof. H. W. Hibbard, Mem. Am. Soc. M. E., Prof. E. A. Fessenden, Jun. Am. Soc. M. E., O. N. Edgar, P. A. Tanner, H. W. Price, F. B. Thacher, F. T. Kennedy, and A. C. Edwards.

PENNSYLVANIA STATE COLLEGE

At the meeting of the Pennsylvania State College Student Branch on May 19, the following officers were elected for the year 1911-1912: J. A. Kinney, president, R. M. Diehl, vice-president, H. S. Rodgers, secretary, and H. E. Davis, treasurer. An interesting lecture on Cleaning of Blast Furnace Gas was given by S. K. Varnes.

SIBLEY COLLEGE

At the meeting of the Sibley College Student Branch held on April 26, Prof. C. F. Hirshfeld, Jun. Am. Soc. M. E., addressed the membership on Modern Tendencies in Gas Power Machinery.

The following officers were elected at the meeting of May 10: F. E. Yoakem, president, G. W. Curtiss, vice-president, L. B. Timmerman, recording secretary, S. D. Mills, treasurer. Certain changes in the constitution and by-laws of the organization were also considered and approved.

On May 13, L. R. Pomeroy, Mem. Am. Soc. M. E., gave an address upon Scientific Accounting, in which he emphasized the importance of the human element in applying the methods of scientific management.

LELAND STANFORD UNIVERSITY

The meeting of the Leland Stanford Mechanical Engineering Society on May 3 was devoted to the election of the following officers: C. H. Shattuck, president; A. G. Budge, vice-president, and C. W. Scholefield, secretary-treasurer. A number of applications were approved for membership.

UNIVERSITY OF CINCINNATI

At the regular monthly meeting of the Student Branch of the University of Cincinnati on May 26, the following officers were elected: C. J. Malone, president, C. W. Lytle, vice-president, Joseph Herman Schneider, secretary-treasurer. A paper on Molding and Foundry Practice was presented by C. W. Lytle and was discussed by the members.

UNIVERSITY OF ILLINOIS

The final meeting of the season was held by the University of Illinois Student Branch on May 12. A paper on a filing system used in a drafting room of a plumbing concern was read by A. F. Connard, and F. J. Schlink gave a talk on the filing system used in a drafting room of a construction and drainage company.

YALE UNIVERSITY

At a meeting of the Student Branch of Yale University held on May 3, a paper on Scientific Management, with special reference to the Piece Rate System, was presented by Frank B. Gilbreth, Mem. Am. Soc. M. E. F. M. Jones was elected president of the organization for the year 1911-1912.

MEETING OF THE COUNCIL

MAY 30

A meeting of the Council was held on Tuesday, May 30, in the Hotel Schenley, Pittsburg, Pa. There were present, E. D. Meier, presiding, Charles Whiting Baker, George M. Brill, W. F. M. Goss, James Hartness, E. M. Herr, H. G. Reist, Jesse M. Smith, Worcester R. Warner, C. J. H. Woodbury, representing the Committee on Meetings, and the Secretary.

The Council received a delegation from Cleveland, Ohio, which presented an invitation from the Cleveland Engineering Society, the Cleveland Chamber of Commerce and the Cleveland Manufacturers Club, offering the City of Cleveland as the meeting place of the Society in the Spring of 1912.

The resignation of Alex. C. Humphreys as a member of the Executive Committee was received and accepted with regret. H. G. Reist was elected to fill this vacancy.

Voted: That advance copies of papers may be printed for local committees and professional sections without consideration by either the Committee on Meetings or the Publication Committee, when within the appropriation of the local committee or section, as the case may be.

Voted: That the following note appear on all copies of such papers: This paper is to be presented at a meeting of The American Society of Mechanical Engineers in ———————— on ———————— and is printed by the Committee in charge of that meeting under its authority.

Voted: To confirm the basis of affiliation between this Society and the Providence Association of Mechanical Engineers.

Voted: That the following Committee, nominated by the members of the Society in New Haven, E. S. Cooley, E. H. Lockwood, L. P. Breckenridge, F. L. Bigelow, H. B. Sargent, be appointed in charge of the meetings of the Society in New Haven for the remainder of the present calendar year.

Voted: To appropriate $75, subject to the approval of the Finance Committee, for the conduct of meetings in New Haven for the balance of the fiscal year.

Voted: To approve the recommendation of the Publication and Finance Committees for the following appropriations:

Distribution of Transactions, Vol. 30	$209.00
Distribution of Vol. 30 and Vol. 31 to members joining the Society December 1908–1909	316.83
For completion of Transactions, Vol. 31	500.00
For text section of The Journal	1400.00
For advertising section of The Journal	3900.00
	$6325.83

Voted: That the policy of the Committee on Meetings be heartily commended in its provision of sub-committees to deal with special industries or departments of engineering. Such sub-committees appear to be an excellent method by which the Society can give proper attention to departments of engineering not represented by organized groups or sections of the Society. When, however, any group of members of the Society, interested in a special branch of engineering, desires to organize as a professional section under the Rules, the sub-committee dealing with said branch should be discontinued or merged into such section.

Voted: To approve the recommendation of the Committee on Constitution and By-Laws, presented by Jesse M. Smith, temporary Chairman.

Voted: To appoint H. G. Stott, upon the recommendation of the Committee on Constitution and By-Laws, to fill the vacancy on that Committee caused by the death of Charles Wallace Hunt.

The following proposed amendment to By-Law 20 was read:

The annual subscription price of The Journal shall be one dollar to Honorary Members, Life Members, in the various grades, Members, Associates, Juniors and Student-Affiliates; two dollars to Affiliates of the Society paying dues, members of affiliated societies who do not pay dues, members of the American Institute of Electrical Engineers, members of the American Institute of Mining Engineers, members of the American Society of Civil Engineers, libraries and colleges; five dollars to non-members not included in the above.

Voted: To amend Rule 24 to read as follows:

Engineers and others not members of the American Society, but desiring to participate in the meeting of the section, may enroll themselves as affiliates as heretofore provided, with the approval of the Executive Committee of the section. Such affiliates shall have the privilege of presenting papers and taking part in the discussions. They shall pay three dollars per annum, which shall be due and payable in advance, on October 1, of each year of their enrollment, and shall thereby be entitled to receive the regular issues of The Journal for a period covered by their dues.

Voted: To approve the following new rule, to be inserted between the present Rules 27 and 28:

The dues of a student to secure affiliation with the Society shall be one dollar per annum, which shall be due in advance of January 1st, of each year.

Voted: To amend Rule 29 to read:

The American Society of Mechanical Engineers will furnish monthly issues of The Journal to all members of affiliated organizations who are not members of The American Society of Mechanical Engineers upon the payment by each of one dollar per year, such payment being due in advance on January 1 of each year. The American Society of Mechanical Engineers will furnish gratis to each affiliated body, extra copies of advance papers for use at its meetings, the number furnished to be agreed upon at the discretion of the Secretary.

Voted: To accept the resignations of R. S. Woodward, E. P. Jump and R. E. Lee.

Voted: To appoint William Kent, W. B. Snow, M. L. Cooke and J. R. Bibbins a committee, with power to increase their number, on the subject of the standardization of catalogues, to report to the Council at a later date.

Voted: To refer to the Tellers of Election of Officers a letter received from George A. Orrok, in regard to improving the form of ballot for officers, with the request that they prepare a report to the Council at a later meeting.

Voted: To confirm the appointment by the President of Charles R. Richards as Honorary Vice-President to represent the Society at the National Irrigation Congress in Chicago, December 5–9, 1911.

Voted: To appoint H. G. Reist on the Council of the American Association for the Advancement of Science.

Voted: To appoint, on the recommendation of the Executive Committee, W. F. M. Goss, on the John Fritz Medal Board, to fill the vacancy caused by the death of Charles Wallace Hunt.

Voted: To appoint, on the recommendation of the Executive Committee, F. R. Hutton, on the Committee of Society History, to fill the vacancy caused by the death of Charles Wallace Hunt.

The minutes of the meeting of April 10 were approved as written.

The meeting adjourned to June 1.

JUNE 1

A meeting of the Council was held on June 1, on board the boat "Sunshine," during the Pittsburg meeting. There were present E. D. Meier, President, Charles Whiting Baker, E. M. Herr, H. G. Reist, W. F. M. Goss, George M. Brill, Jesse M. Smith, and the Secretary.

Voted: That the Spring Meeting of 1912 be held in Cleveland.

Voted: That the matter of second-class rates of postage be referred to the Executive Committee with power.

Voted: To approve the formation of a Student Branch at Lehigh University.

NECROLOGY

MORRIS LANDA ABRAHAMS

Morris Landa Abrahams died on March 28, 1911, at San Antonio, Texas. Mr. Abrahams was born on March 21, 1885, at Austin, Texas, and after a preparatory education at the Hogsett Military Academy, Danville, Ky., and the Agricultural and Mechanical College of Texas, entered Cornell University, from which he was graduated in 1905 with the degree of M. E. Previous to his matriculation at Cornell he had acquired practical experience with the Deming Company, Salem, Ohio, in their drafting room, and with the Dean Brothers Steam Pump Works, Indianapolis, Ind., as assistant to the foreman of the testing floor. In 1907 he entered the employ of Walter S. Timmis, consulting engineer, New York City, where he engaged in power plant design, printing plant layouts, the development of a patent elevator safety device, heating and ventilation, and other similar phases of mechanical engineering. Later in the same year he left Mr. Timmis to become a member of the engineering force of the Victor Talking Machine Company in Camden, N. J. In 1910 he entered the service of the Government as assistant chief inspector attached to the Canal Commission, with headquarters at Washington, and retained this position until shortly before his death, when illness obliged him to resign his duties.

PAUL RAYMOND BROOKS

Paul Raymond Brooks was born in Chicago, Ill., August 17, 1877, and was educated at the Chicago Manual Training School and the Massachusetts Institute of Technology, from which he was graduated with the degree of B.S. in 1900. Following his graduation he entered the employ of the Chicago, Burlington & Quincy Railroad, where he began in the locomotive shop as an apprentice and worked his way through successive promotions to the position of acting foreman of the Burlington roundhouse of the company. In 1904 he became Western mechanical editor for the McGraw Publishing Company, New York. The following year he became a sales engineer for the Railway Appliances Company and the Otto Gas Engine Works, and in 1908 general sales manager for the Machine Sales Company, Peabody, Mass. In 1909 he associated himself with the Union Bag & Paper Company, Sandy Hill, N. Y., as mechanical engineer, and at the time of his death on March 11, 1911, was president and superintendent of the Del Monte Irrigation Company, Texas.

JOHN A. CALDWELL

John A. Caldwell was born August 12, 1849, at Johnstone, Scotland, and was educated at the Glasgow School of Design and Mechanical Engineering, from which he was graduated in 1867. He served his apprenticeship as a pattern maker with the firm of Tweedale & Robinson, Johnstone, and as draftsman with Lawson & Son, Glasgow, from 1863 to 1868. In 1870 he came to the United States and was employed by Mackintosh, Hemphill & Company of Pittsburg, for whom he designed large rolling mills and blast engines, and had entire charge of relining the Schoenberger blast furnaces and rebuilding the hot blasts at Pittsburg, as well as the erection of two new blast furnaces at Port Washington, Ohio. He subsequently designed all the locomotives built by the National Locomotive Works, Connellsville, Pa., the Alice stamp mill and the Moulton mill at Butte, Mont., the elevator service for Z. C. M. I. at Salt Lake City, Utah, the stamp mill at Parrall, Mexico, the numerous filter plants for the Hyatt Pure Water Company, including the installation of the city plant at Oakland, Cal., and was in charge of the new engine and boiler installations for the H. W. Johns Manufacturing Company, Brooklyn, N. Y., contracted for and superintended the erection of numerous blower plants, water pumps and pumping stations for the P. H. & F. M. Roots Company, including the pumping station at Little Falls, N. J., and contracted for, designed and superintended the erection of numerous water-tube boiler plants, including piping, in conjunction with James Beggs & Company. In 1899 Mr. Caldwell became business manager for the American Stoker Company, New York, and in 1901 opened an office of his own in the same city, making a specialty of boiler room economies, particularly stokers and CO_2 recorders. He died on April 7, 1911.

CHARLES J. LARSON

Charles J. Larson was born on March 2, 1872, at River Falls, Wis. His early education was obtained at the State Normal School, Morehead, Minn., and at Macalester College, St. Paul, Minn., and his technical training at the Rose Polytechnic Institute, Terre Haute, Ind., from which he was graduated in 1900 with the degree of B. S., and from which he also received the degree of M.E. in 1909. In 1900 he entered the employ of the Allis-Chalmers Company at Milwaukee, as erecting engineer, and from 1905 to 1907 had supervision of the installation, operation and testing of machinery furnished by this company in the Eastern territory. Among the prominent engineering works which he superintended in this capacity were the Washington drainage system and water works, the Boston sewerage system, the Boston elevated railway, the New York subway engines, the New York high-pressure service, and the Midvale Steel Company's plant and machinery for the Connecticut Railway Company. In 1904 he installed and had charge of the operation of the 6000-h.p. Allis-Chalmers-Bullock exhibit at the St. Louis Exhibition.

He was forced to resign his work in 1908, because of ill-health and accepted a position as chief engineer of the Union Electric Company, Dubuque, Iowa, which he held at the time of his death on April 6, 1911.

Mr. Larson was a member of the American Institute of Electrical Engineers and the National Electric Light Association, and had made many valuable contributions to technical journals.

EDWARD B. YARYAN

Edward B. Yaryan who was born in Toledo, Ohio on April 10, 1881, died in that city on April 28, 1911. Mr. Yaryan began his professional career in 1896 with the Toledo Heating and Lighting Company as a steam engineer. From 1900–1902 he was manager of a central station at Evanston, Ill., and was at the same time employed as superintendent of construction for the Oak Park Yaryan Company of Oak Park, Ill. The following year he re-entered the service of the Toledo Heating and Lighting Company as its superintendent, leaving there in 1906 to become vice-president of the Maclaren & Sprague Lumber Company of Toledo. In 1908–1909 he became superintendent of the Yaryan Process Company of the same city, and in the following year of the Yaryan Naval Stores Company, in the service of which latter firm he later went to Gulfport, Miss., where he remained until shortly before his death.

RECIPROCATING BLAST-FURNACE BLOWING ENGINES

By W. Trinks

ABSTRACT OF PAPER

The causes for the gradual change and progress in reciprocating blowing-engine practice are set forth. An elementary study of valve motion is given and the valve gears of present standard American practice are described. It is shown that these engines are very successful at the speeds for which they were designed, but that at higher speeds they cannot be used successfully, so that new designs had to be brought out in order to meet the pressing demand for higher speeds and lower first cost. Two American designs are described. It is shown that these valve systems, although much superior to the so-called standard gears when used for high speeds, have not yet broken with the idea that smallness of clearance is required for economy, whereas German builders have demonstrated that by the use of multi-ported plate valves large valve areas and economy at high speed operation can be obtained in spite of large clearance. The foremost European types of plate valves are described and the results of tests are given.

It is pointed out that the bringing up of the piston speed of the blowing engine to the standard piston speed of the power gas engine or the power steam engine reduces the first cost of the reciprocating blower and that the combination of the high-speed blast-furnace gas engine with a high speed blower constitutes the most economical method for the production of furnace blast.

RECIPROCATING BLAST-FURNACE BLOWING ENGINES

By W. Trinks, Pittsburg, Pa.

Member of the Society

In the last 20 years American blowing-engine practice has assumed rather set forms. The growing size of furnaces has increased blast pressures to a point where the heat of compression has made the use of felt, canvas, or leather valves impossible. Certain forms of valves and engine types have been developed which have dominated the market for a number of years, and their operation furnishes today the blast for more than 90 per cent of the pig-iron capacity of the United States. But a few years ago the contentedness of American builders and users of blowing engines was rudely shattered by a double European invasion: the gas engine and the turbo-blower.

2 The gas engine, although much more economical of fuel than the steam engine, is more expensive with regard to first cost. To reduce the cost per horsepower, high piston speed must be employed; thus the piston speed has been increased from the 300 ft. per min., heretofore considered standard in steam-driven blowers, to 600 ft. per min. in modern American gas-driven blowers. In Europe reciprocating blowers run at piston speeds of 750 ft. per min.; the gas engine for generation of power runs today at piston speeds very close to 1000 ft. per min.

3 The turbo-blower appeared on the market a few years ago first on the European continent, where its progress was completely checked by the price of coal. The steam turbine could not compete with the low fuel consumption of the gas engine. Recently the turbo-blower has also been introduced in this country. Here the lower price of coal and the higher price of operating labor will favor its introduction in a few districts, but the old law that progress in one line of business invariably begets progress in a competing line is true also in this case, and thus we find builders of reciprocating

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engines busy making improvements and raising the standard of their product.

4 The understanding of the reasons why the standard types of American blowing engines are so successful at medium speeds and what their shortcomings are at high speeds will be much facilitated by a short study of valve motion and of throttling losses through valves.

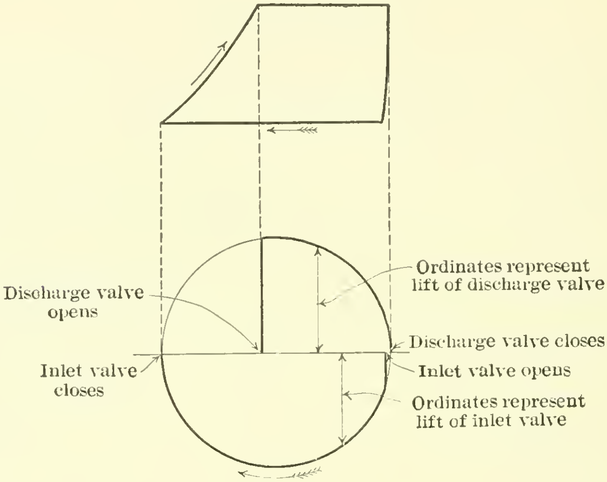

Ordinates represent lift of discharge valve
Discharge valve opens
Discharge valve closes
Inlet valve closes
Inlet valve opens
Ordinates represent lift of inlet valve

Fig. 1 Ideal Valve Motion of Pumps or Compressors on Displacement Basis

5 It is proved below that high velocity through valves is harmful; the tendency is therefore to keep the velocity at a fairly constant low value; and since the piston of an engine has very nearly harmonic motion, it follows that the valve should also have harmonic motion, if a constant and small pressure drop is desired. On a displacement basis harmonic motion becomes a circle. Fig. 1 shows the valve lift on a displacement basis. The inlet valve is open practically throughout the stroke; the outlet valve should pop open near the middle of the stroke and close at the end.

6 Fig. 2 shows this same ideal diagram on a time basis. It will be noted that the curves intersect the base line at an angle, indicating that if these ideal motion curves are realized the valve will strike a blow in seating. The velocity of striking depends upon the lift of the valve and upon the time of one revolution, which

means that high-lift valves, while successful for low rotative speeds, become impractical for high rotative speeds.

7 Consciously or unconsciously, engineers have striven to design valves and valve gears for blowing engines so that the above valve motion curves are approximated. Two circumstances interfere with attaining the ideal; one is the quantity of air under a lift valve, which lessens the discharge through the valve during its lift and increases the discharge during the closing period; the other is the mass of the valve which has baffled designing engineers quite often. The author published 12 years ago, when his experience was mainly theoretical, formulae for designing valves and springs in such a way that the pressure difference on the two sides of the valve and the impact of the air flowing through the valve would be nicely balanced by the spring and that the ideal valve lift curve could be attained. He was very much surprised by valve vibrations, when the formulae were put to a test. As a pendulum swings about its position of equilibrium, so a valve will vibrate about its ever changing position of equilibrium, if it is designed to float between the air pressure and current on one side and the spring on the other side. A typical (diagrammatic) valve lift curve is shown in Fig. 3. A diagrammatic or made-up curve was preferred to a curve taken from a particular engine, because an endless variety of vibrations is possible depending upon the mass and shape of the valve and upon the spring loading. It should be understood that the fluttering of the valve occurs to this extent only if no means have been provided for damping it, and that the heavier the valve the more energy the damping consumes. In Fig. 3 the valve is shown to close late.

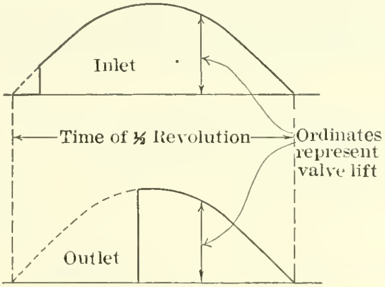


Fig. 2 Ideal Valve Motion of Pumps or Compressors on Time Basis

Practically all automatic lift valves close late, depending upon rotative speed of engine, lift of valve and spring loading. The lower the rotative speed and the valve lift and the greater the spring load closing the valve, the nearer the valve is to the seat in the dead center position of the crank. Tests and calculations show that in ordinary American blowing-engine practice the valves close so near the dead center that for all practical purposes they may be considered as closing "on time" and without the injurious effects of late closing, namely, slipping back of air and hammering of valve.

8 The behavior of the outlet valves is similar to that of the inlet valve with two exceptions. First, the valve has to open when the piston moves fastest; secondly, the pressure difference on both sides of the valve increases rapidly at the dead center. In Fig. 4 the ideal and the actual valve-lift curves are shown in connection with an indicator card on a displacement basis. The slower the rotative speed of the engine, the lighter the valve and the smaller its lift, the more perfect is the approximation to the ideal lift curve. High rotative speeds, heavy valves and small areas uncovered by the valve for a given lift cause the pressure in the cylinder to rise considerably over that existing in the blast space and store up considerable amounts of kinetic energy in the valve which must be taken care of by a cushioning device; otherwise fluttering or hammering results. As already stated, the pressure drops rapidly under the valve immediately after the crank has passed the dead center, and particular care must be taken to have the valve close promptly in order to avoid hammering.

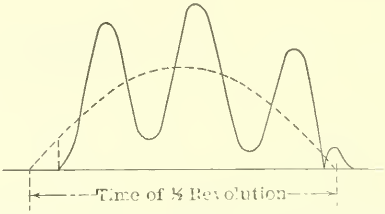


FIG. 3 ACTUAL MOTION OF HEAVY, NON-CUSHIONED INLET VALVES (TIME BASIS)

9 Throttling loss through valves involves two factors: loss of velocity head and surface friction. The vast majority of valves are so designed that surface friction, such as occurs in long pipes or ducts, is practically absent. For this reason, losses due to velocity

head only will be investigated here. Fig. 5 gives the throttling loss for various piston speeds and for various ratios of valve area to piston area. In this chart, valve area does not mean the so-called free valve area which is a rather imaginary or conventional quantity, but it means the area actually offered to the air-flow at the narrowest place of the valve. It is assumed that the valve has harmonic motion and that the coefficient of discharge is 70 per cent. For a number of valves this latter figure was found to agree most closely with tests.

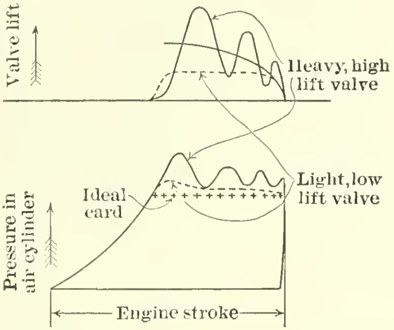
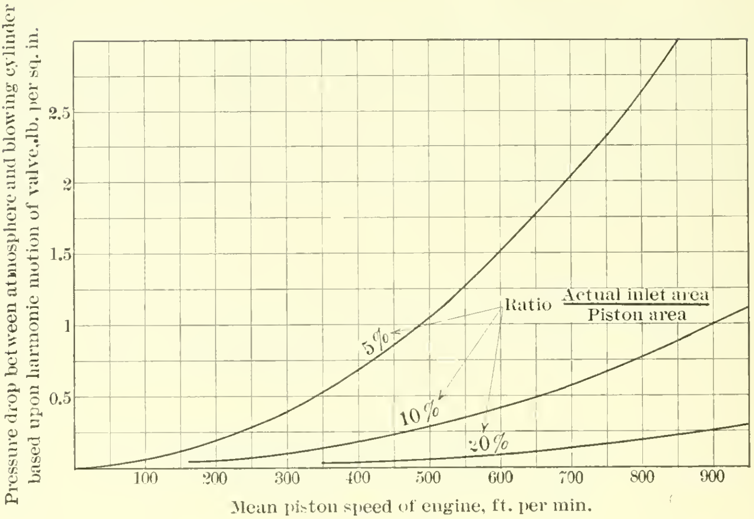


FIG. 4 ACTUAL MOTION OF OUTLET VALVES (DISPLACEMENT BASIS)

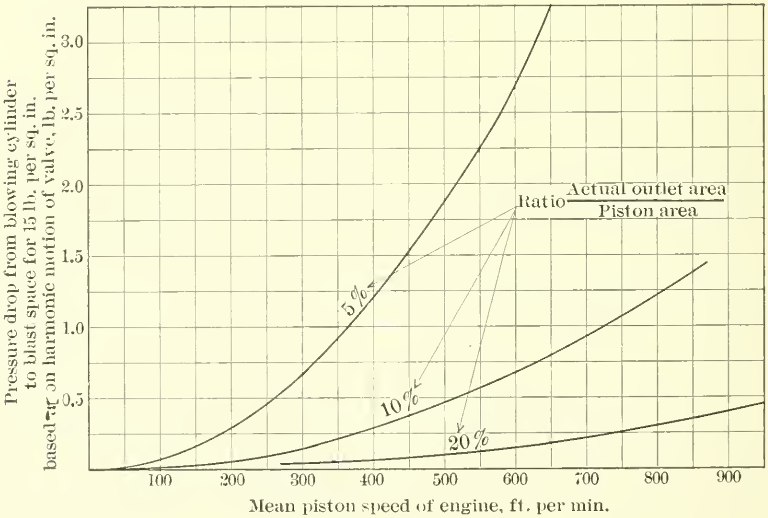
10 It will be observed that for a piston speed of 300 ft. per min., which up to a few years ago was standard in this country, and for inlet areas of 12 per cent, outlet areas of 9 per cent, the pressure drop due to throttling is a negligible quantity compared with the mean effective pressure (say 11 lb. per sq. in.) of the air card.

11 With a stroke of 60 in., so common for blowing engines, a piston speed of 300 ft. per min. means 30 r.p.m. At this low rotative speed the spring loading required to close the valves on time is so small that the inlet and outlet areas of 12 and 9 per cent can be realized.

12 Further penetration into theory would be out of place here. A better idea of the evolution of the modern blast-furnace blowing engine may be gained by the study of standard types. Fig. 6 illustrates a design which for the last 15 years has been very popular in the United States. The inlet valve is mechanically operated throughout and is a balanced piston valve. Mechanical operation of valves has been practised for over 20 years and avoids many of the troubles incidental to an improperly designed automatic valve. No fluttering



(*a*) Inlet Valves



(*b*) Discharge Valves

Fig. 5 Pressure Loss in Blowing-Engine Valves due to Velocity Head

or chattering can occur, a full port opening may be obtained and the valve may be made to open and close even more rapidly than is required by the ideal sine curve. The breaking of a mechanically operated slide valve is also highly improbable and great reliability therefore results. The outlet valve is a cup, opening automatically by air pressure and closing by mechanical means. The cup cushions without springs against the movable plug, so that fluttering or chattering is impossible; it is fairly light and at rated speed opens with small throttling loss. If the valve gear is properly adjusted, the outlet valve closes at the right time, so that hammering, due to late closing, cannot occur. The number of valves to be looked after is small because a few large, light-lift valves are employed, usually two inlet valves and two or three outlet valves. The valve

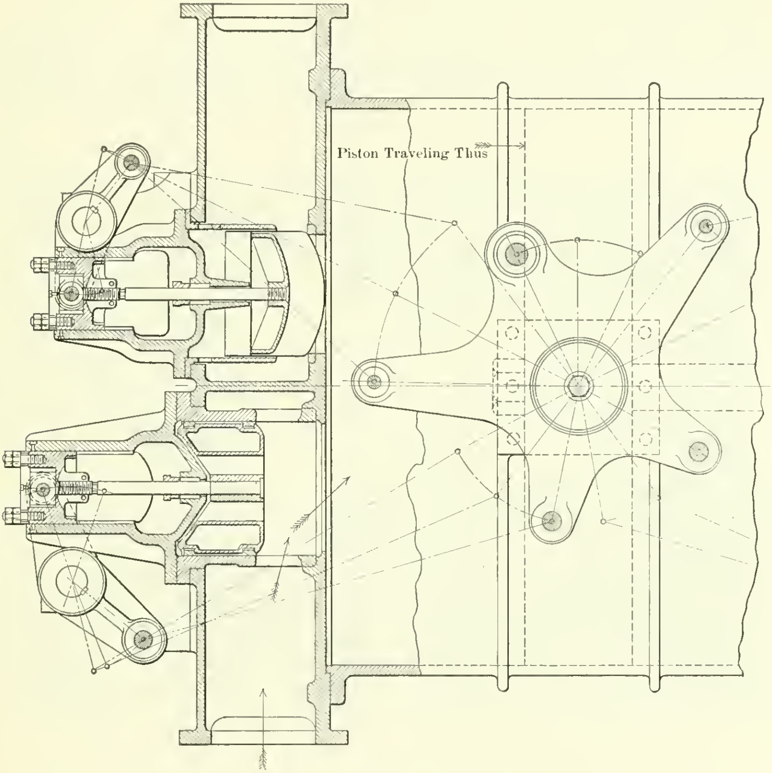


Fig. 6 Valve Gear built by Allis Company

gear pins are made so large that very little wear can occur. This precaution keeps the valve gear in correct adjustment.

13 The principles underlying this design are very sound, and its success is well deserved. With engines of 60-in. stroke it is at its best with speeds between 30 and 40 r.p.m. The builders do not recommend it for speeds exceeding 50 r.p.m. At that speed the pressure in the cylinder at the end of the suction stroke is $\frac{1}{2}$ lb. per sq. in. below that of the atmosphere.

14 A very similar valve gear is illustrated in Fig. 7. Here the inlet valve is double-ported for the purpose of quick opening and closing. The outlet valve cushions in opening against a stationary plunger and is mechanically closed by a central pusher. In design it is similar to Fig. 6.

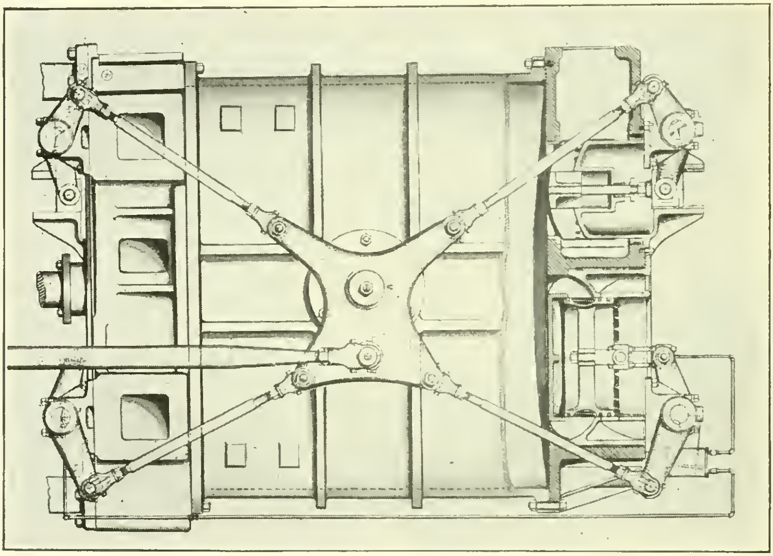


Fig. 7 Valve Gear built by Wm. Tod Company

15 The fact that two valve gears of such close resemblance, and built by competing firms, could have been patented independently indicates that the valve gear must have good features. It would also seem probable that it was originated in one place and copied in another. As a matter of fact, the outlet valve originated in one concern, the inlet valve in another, and by mutual borrowing two good valve gears were produced.

16 These two valve gears as well as others of standard American design employ mechanically operated, or positively driven, inlet valves. As long as the clearance volume of the engine is small, mechanical operation of the inlet valve is scientifically correct, because the opening and closing points of the valve (Fig. 8) remain practically fixed in spite of variations of blast pressure. Matters are quite different with the outlet valve. Its correct opening point varies with the blast pressure and losses occur, as indicated in Fig. 8, if the valve opens at a fixed point and if the blast pressure differs from the one for which the engine was designed. Julian Kennedy, of Pittsburg, reasoned, however, that the gain in reliability by the use of mechanically operated outlet valves would easily offset these losses and that the "work on the engine, due to advance opening of the valve, is probably not in excess of the work required in the case of a poppet valve due to the crowding of the pressure above the receiver pressure due to the opening of the valve." Fig. 9 shows his design and Fig. 10 indicator cards taken from an engine of this type. It will be noted that inlet and outlet valves are balanced piston valves. The piston which is not shown in Fig. 9 is scalloped out to fit around the valves with a view to reducing clearance volume. The outlet valve opens when a pressure of 7½ lb. has been reached in the cylinder. From that point to the reaching of the blast pressure (Fig. 10) the indicator card is a combination of compression and air discharge from the receiver back into the cylinder. An inspection of the indicator card with regard to smallness of lost work shows that Mr. Kennedy is right. The engines built on this principle are outwardly quite successful, and no repairs have been necessary on engines now in operation for over seven years.

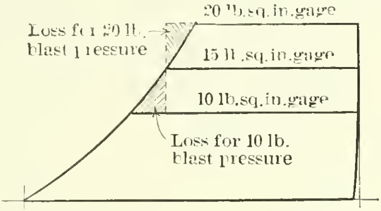


Fig. 8 Loss caused by Mechanically Operated Outlet Valves

17 It is somewhat surprising that a valve gear which positively opens large areas, avoids valve fluttering and prevents slip by timely

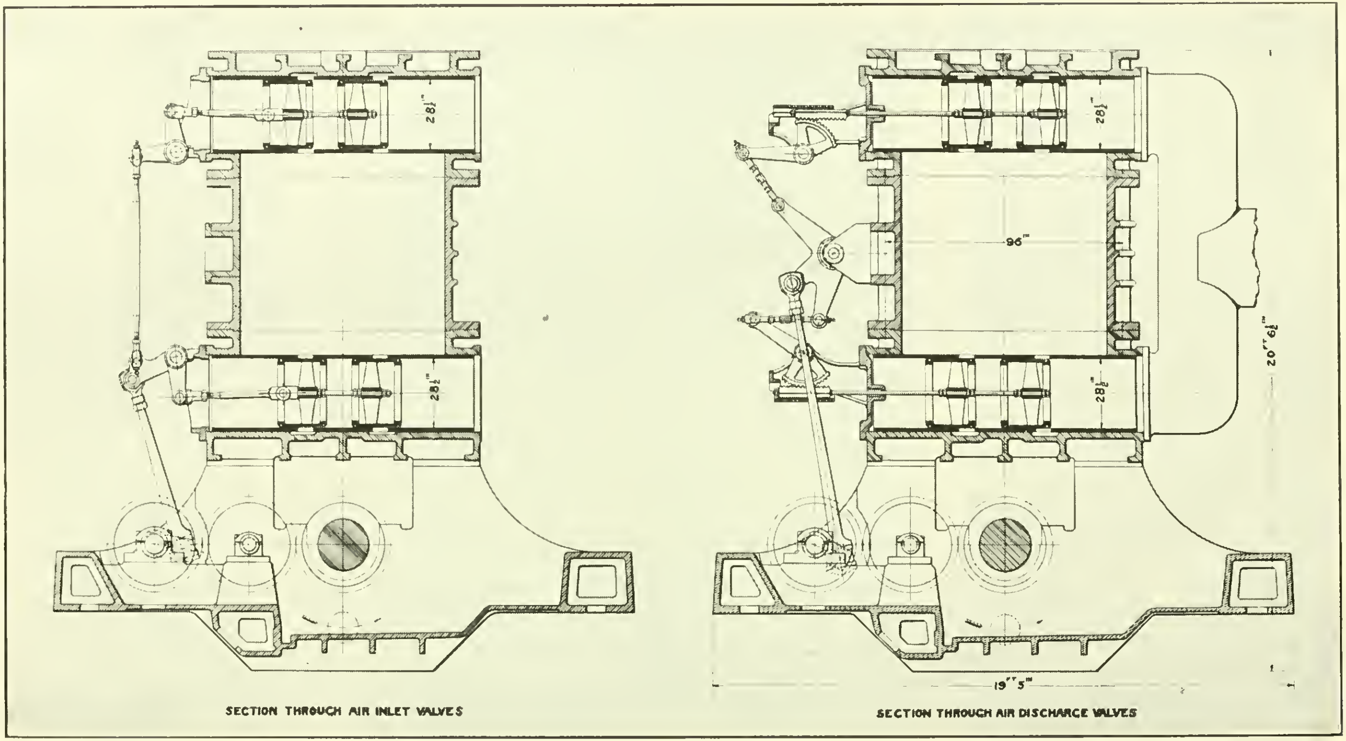
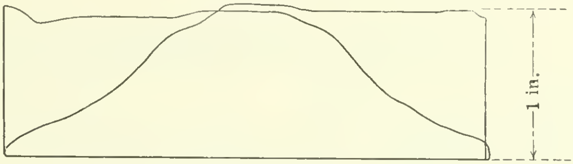

28½″
28½″
96″
28½″
28½″
20′ 6⅜″
19′ 5″
SECTION THROUGH AIR INLET VALVES
SECTION THROUGH AIR DISCHARGE VALVES

Fig. 9 Cylinder with Mechanically Operated Inlet and Outlet Valves (Design of Julian Kennedy)

closing of valves should have been limited to less than two dozen engines. The author believes that the following reasons may have contributed in preventing a more general adoption of the system: (*a*) the large number of pins, rods and levers create the impression of complication; (*b*) large relief valves must be provided to prevent wrecking of the engine in case of accident to the valve gear; and (*c*) the slower the speed of the engine, the greater the work required per stroke due to the pre-opening of the outlet valve. Below a certain speed, if the engine is run with wide-open throttle on the governor, a peculiar tendency to hunt is the result.

18 Among the means employed to prevent fluttering of lift valves the dash pot has always played a prominent part. Fig. 11 shows a typical outlet valve in connection with a dash pot or cushioning chamber. Regulating valves or pet cocks are placed above and below the cushioning piston to provide for any desired or necessary degree of sluggishness. This type of valve has been used by several engine builders.



1 in. represents 20 lb.sq.in. on original card
Dia. of cylinder 96 in.
Stroke of engine 66 in.
32 r.p.m.

Fig. 10 Indicator Card taken from Engine shown in Fig. 9

19 Fig. 12 shows a design employing the outlet valve described in Par. 18. As usual the inlet valve is mechanically operated. It is of the rocking valve type and is so arranged that clearance volume is kept down to a small value. The power required for operating the inlet valve is quite small, because the latter moves very little when it is unbalanced. When this type of valve was first used by the present builders about ten years ago, the author expressed the opinion that the valves would be very short lived, owing to wear by the dust laden atmosphere of furnace plants. Actual experience, however, has proved that these valves do very well and that the wear is small. Free inlet areas amounting to $11\frac{1}{2}$ per cent of the piston area can easily be obtained by this valve and a greater per cent be secured by a slight increase in the clearance volume. The area through the

holes under the outlet valve discs is 16½ per cent of the piston area. To utilize this area to the fullest extent the outlet valves would have to lift 3½ in. For reasons which will be explained, a lift of this size is impractical, except for low rotative speeds, when it is of course not needed, so that in practice a lift of only 2¼ in. is used, cutting the available outlet area down to 11 per cent of the piston area. A large number of blowing engines with this valve gear are in successful operation both in the United States and in Canada.

20 What may be termed the most original of all blowing-engine valve gears is shown in Fig. 13. Inlet and outlet valves are of the gridiron type of 1⅞ in. stroke. The inlet is controlled by a cam acting in pair closure and the outlet valve is pulled open by the piston of an actuating cylinder. One side of the piston is open to atmosphere, the other side to the blowing cylinder. As compression proceeds in the latter, the friction holding the valve in position becomes less, and the force tending to displace it grows. The actuating cylinder is so proportioned that for a given speed of engine, for a given blast pressure and for a given method of lubrication, the valve opens at the correct instant. The kinetic energy of the moving valve is dissipated in a cam-operated dash pot which closes the valve at the dead center of the engine.

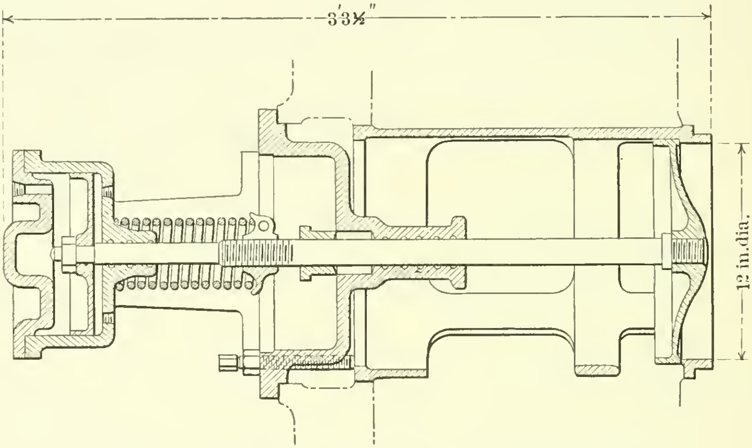


Fig. 11 Automatic Discharge Valve with Dash Pot

21 Fluttering of valves is most successfully avoided, large areas for inlet (14 per cent of piston area) and for outlet (11 per cent) can

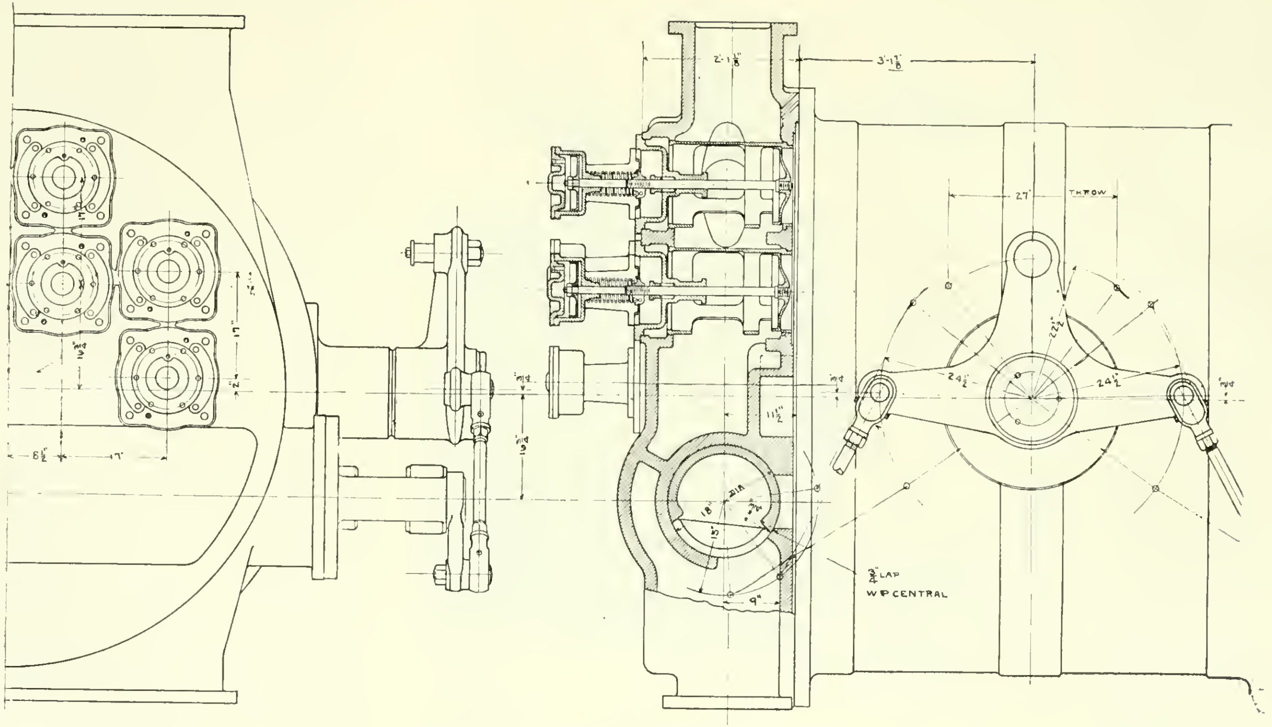


Fig. 12. Original Mesta Valve Gear

be obtained, and the power requirements are small. Ten and twelve years ago this type of valve gear (Fig. 15) was very popular in the United States and several engines of this type have been built in England and Belgium, but comparatively few have been constructed in recent years. It is not easy to determine the reason for the rise and fall of popularity in blowing-engine valve gears, but the following statements may throw light upon the subject. In several furnace plants the wear of the gridiron valves caused leakage losses so that replaning of the valve seats became necessary.[1]

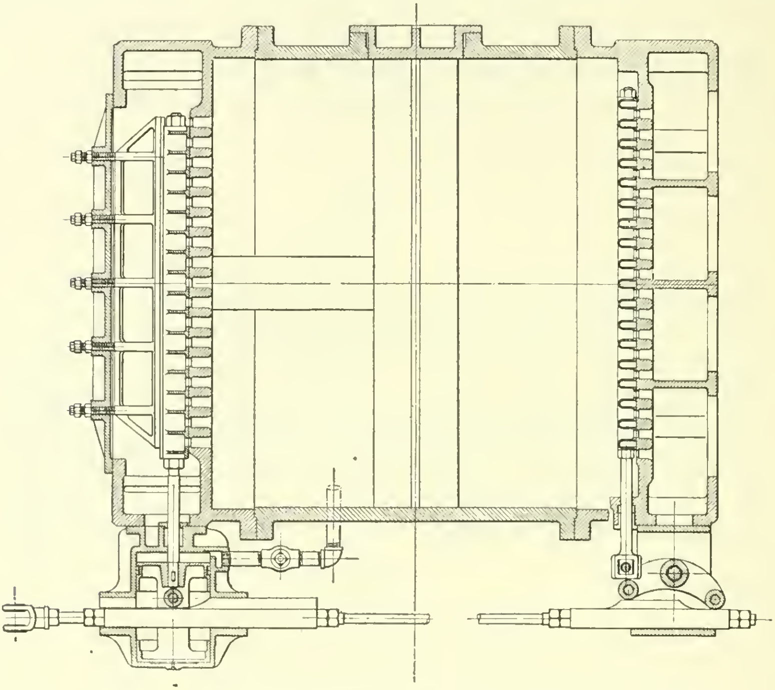


Fig. 13a Section through the Southwark Valve Gear

The air cylinder needs large relief valves to prevent injury to the engine in case of accident to the valve gear. Owing to the fact that at slow speeds the outlet valve opens much too early, more work is done per stroke at low speeds than at high speeds, even more than that done in the design of Fig. 9, and serious hunting occurs, when the engine is run on the governor with throttle wide open.

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[1] Since this paper was read the author has been advised by the builders that in the engines in question aluminum valves were used which imbedded dust and grit and ground out the valve seat. Where cast iron valves are used, the wear is considerably smaller.

22 Every one of the valve gears so far described gives most satisfactory results at a piston speed of about 300 ft. per min. In Par. 2 the fact has been mentioned that the insistent demand for lower first costs requires higher piston speeds, not only temporarily in emergency cases, but continuously. Naturally, the experiment of running the standard types of valve gears at higher speeds was tried. Comparatively little trouble was experienced with the mechanically operated inlet valves, except that in some of the designs the throttling loss is much greater than might be expected from Fig. 5. This is due to the passing of the air around corners in the valves, while it is flowing at high speed (see Fig. 6 and Fig. 7). Since it is easy to observe the inlet throttling loss on an indicator card by drawing the atmospheric line, it attracted attention and was probably given undue prominence. Phrases such as "small volumetric efficiency," and "inability to fill the cylinder" were often heard. The much greater, but invisible, loss of volumetric efficiency, due to heat interchange between air and cylinder walls, was hardly ever mentioned in this connection.

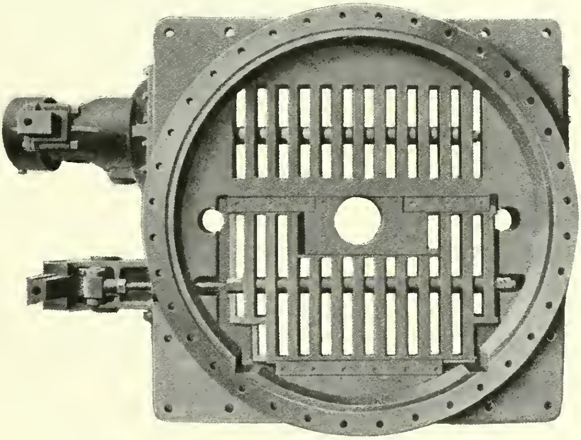

Fig. 13b View of Southwark Cylinder Head

23 Thus the "standard" valve gears gave at 600 ft. per min. throttling losses ranging from 0.4 to 1 lb. per sq. in., and engineers were trying to increase inlet valve areas up to 20 per cent or more. At the discharge end serious troubles occurred with increase of speed. In the designs of Fig. 6 and Fig. 7 rapid wear of the valve seat and hammering of the valves occur. Whether this is due to a throwing of the valve against its seat by the plunger or to other causes is not certain.

24 In the design shown in Fig. 12, quietness of operation can always be enforced, even at the highest speeds, but the spring loading on the valve must be increased and its lift in the dash pot must be reduced. Considerable throttling loss is then encountered. All designs using large, heavy, high-lift valves experience in common an excessive hump on the card at the time of the opening of the discharge valve, because it takes too long to provide the necessary area for discharge. The type shown in Fig. 13 is free from this evil provided very large actuating cylinders are used, but their size only accentuates the trouble in regulation mentioned above.

25 If the American standard valve gears are used for 600 ft. per min. piston speed or above, inlet throttling losses of 3 to 6 per cent of the ideal blowing work occur, and outlet throttling losses of 7 to 12 per cent of the ideal blowing work occur. Besides, power for mechanical operation of valves increases, and other troubles of wear, breakage, or regulation appear depending upon the valve gear.

26 One of the first men to judge the situation correctly was E. E. Slick of Pittsburg. He realized that large areas are necessary and that the periphery of the cylinder may be used for obtaining area, if the cylinder head does not suffice. Attempts to use the periphery are old, but all of them introduced additional clearance volume. The design of Mr. Slick is free from this fault. Figs. 14 and 15 illustrate Mr. Slick's engine as built by two different firms. The cylinder proper or tub is made movable and serves as a mechanically operated inlet valve. Unobstructed inlet areas of 18 to 20 per cent are easily obtainable and practically without clearance space. The outlet valves in Fig. 14 are a modified form of the type shown in Fig. 6 except that the number of valves has been doubled. The outlet valves of Fig. 15 are also an invention of Mr. Slick. They are flexible plates and open against a curved guard. Here, too, large valve areas can be obtained and what is very important, they can be obtained with small valve lift.

27 For piston speeds up to 600 ft. per min. and for rotative speeds up to 65 r.p.m., the Slick tub has been very successful. The design has been severely criticized as "wagging the dog and holding the tail still" and the author confesses that he felt the same way when he saw the first Slick compressor more than ten years ago at the Edgar Thompson Steel Works, but the ingenuity of the design is forcibly impressed upon anybody who attempts to produce the same combination of large areas and small clearance space in some other way. If 65 r.p.m. are exceeded with this type, trouble begins. The

inertia forces of the heavy cylinder are hard to take care of and heat the eccentric which moves the cylinder.

28 In the design of Fig. 14, wearing of valves and seats and hammering of the valves occur. In the design of Fig. 15, the valves break. They are not protected against lateral wind currents which exert a tearing action; furthermore the valves close late, and therefore with a slap, because no closing spring is provided beyond the elasticity of the valve plate itself.[1]

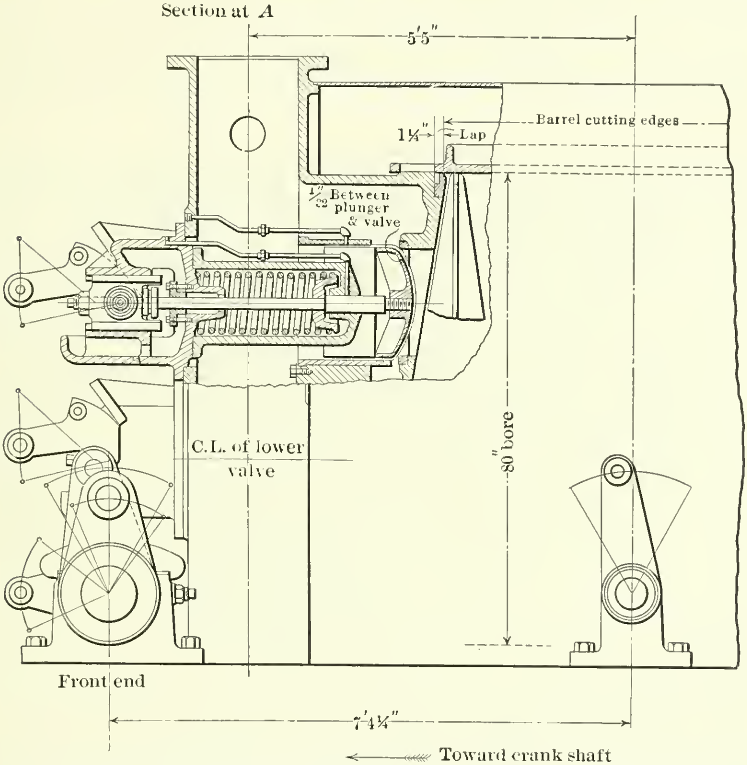

Fig. 14 Blowing Tub with Movable Cylinder (Slick Design) built by Allis Company

29 Another engineer who realized that the standard valve gears will not do for piston speeds of 600 ft. per min. is George Mesta of Pittsburg. Fig. 16 illustrates the manner in which he obtained large inlet and outlet areas and enforced quiet operation of valves. Rock-

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[1] The engineers of the Snow Steam Pump Company, who also build blowing engines on the basis of Slick patents, advise the author that their firm makes the valve seat of Fig. 15b slightly curved, so that the plane valve rests against the seat with an initial tension. The result is that higher speeds can be attained without breaking of valves.

ing valves, two for each head, control both inlet and outlet; the inlet passes at the side of each valve, the outlet through the center of the valve. Automatic cup outlet valves are located beyond the rocking valves and are protected against the return closing slam by the mechanical closing of the rocking valves. This latter design has been used on vacuum pumps and compressors for over 20 years. Its adaptation to high-speed blowing-engine practice required doubling the valve equipment for the purpose of obtaining large areas without excessive diameter of rocking valve. The pot outlet valve is cushioned very little and is loaded lightly so as to fly out of the road of the blast without fluttering.

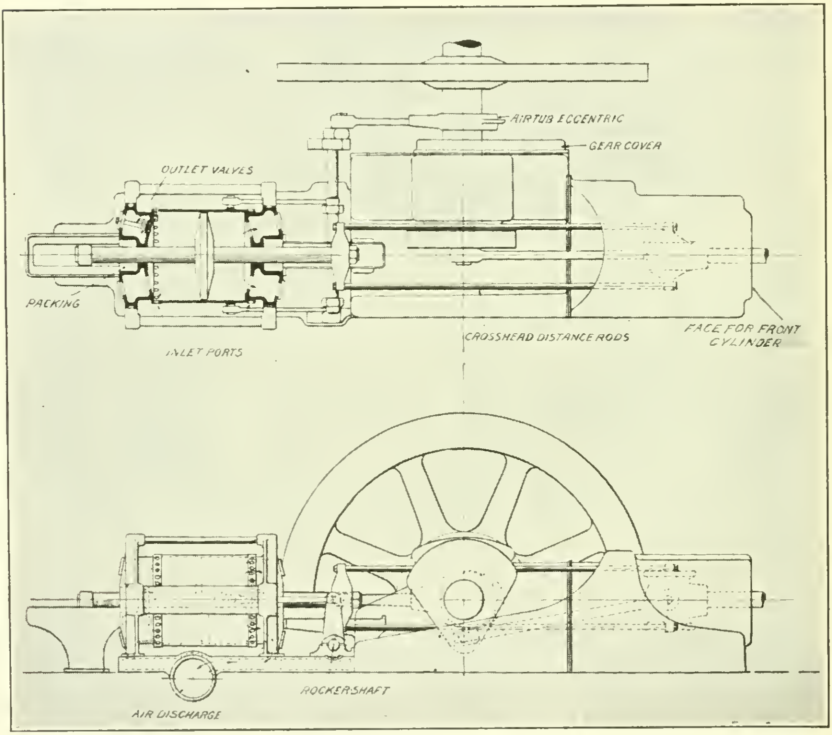


Fig. 15a Blowing Tub with Movable Cylinder (Slick Design) built by Westinghouse Machine Company

30 In Fig. 17 two indicator cards taken from an engine of this type are reproduced. It will be noticed that in spite of the large inlet valve area, 18 per cent, some throttling appears at 70 r.p.m., 700 ft. per min. piston speed. The pressure line in the blast-receiver space has been entered, so that an idea may be gained of the outlet-

throttling loss. Actually the loss is slightly greater than here shown, because calibration of the indicators revealed the fact that their scales were not quite alike.

31 The design of Fig. 16 has been very successful and has been used up to 820 ft. per min. piston speed, 82 r.p.m. with 60 in. stroke. With the exercise of care in finishing the large rocking valves and their seats the resistance of these valves consumes less than 2 per cent of the ideal blowing work (air card). The principal drawback of this type of engine probably lies in its cost and in the oil consumption of the rocking valves.

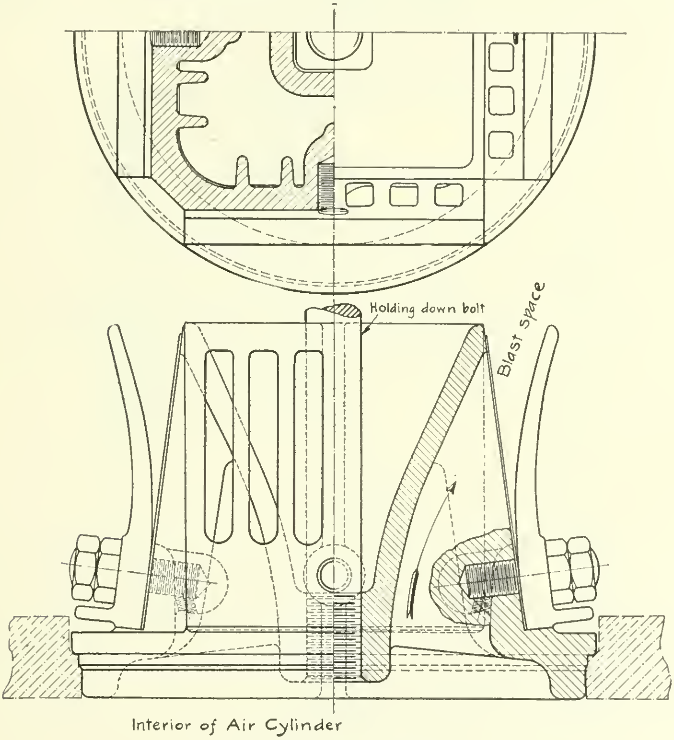


Fig. 15b Slick Air Valve

32 In Europe the high-speed blowing engine is an accomplished fact. There the problem has been attacked along altogether different lines. European engineers long since realized that the harmful kinetic energy stored up in a valve is proportional to its mass and to its travel, and that, therefore, both should be cut down. This fact in itself is not new to American engineers. The Weimer blowing

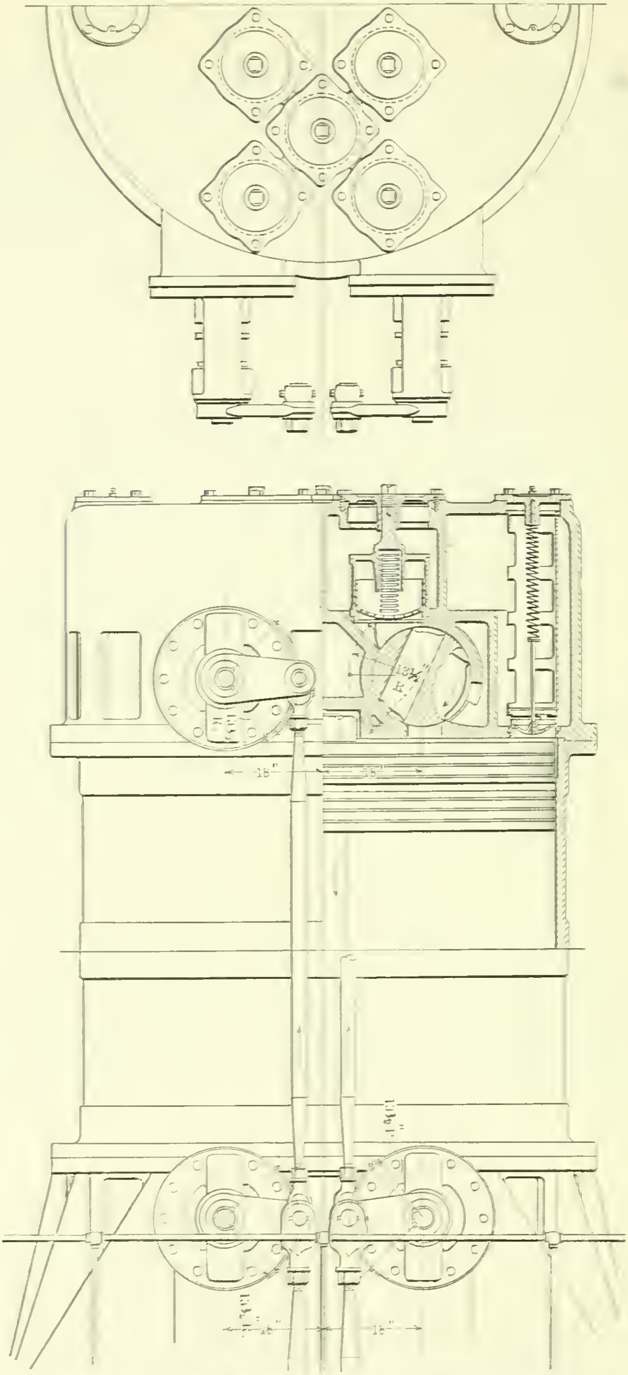
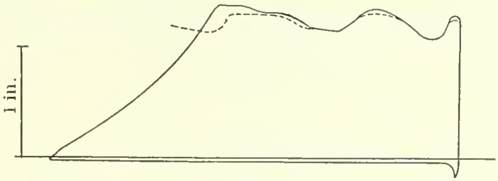


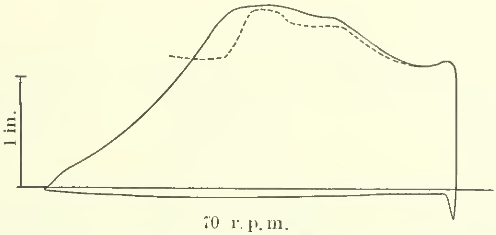
Fig. 16 Blowing Cylinder with Combination Inlet and Outlet Valve (Mesta)

engine (Fig. 18) which can look back upon a respectable number of decades, has tried hard to embody the principle of small mass and low lift. It has failed by sticking to the use of leather which is unsuited to high pressures[1]. Fifteen years ago Mr. Mansfield designed a blowing engine for Leetonia, O., in which he used a great number of light, low-lift strips. The engine failed, not on account of the valves, but because it was "weak in the knees." Mr. Slick (see Fig. 15) introduced light low-lift valves. But these attempts cannot compare with the sweeping success on the other side of the Atlantic.

33 Out of the mass of European designs, two stand out conspicuously, the Hoerbiger (Fig. 19) and the Borsig (Fig. 20). As will be noticed, these valves are of the automatic, multi-ported, low-lift type. They are guided without friction by elastic deformation of part of the valve. To get enough valve area, the cylinder head must be extended considerably beyond the piston diameter (Fig. 21), or a valve belt must be used and the clearance correspondingly increased. It should be noted that there is no novelty in the valve belt as such. It was used 20 years ago, both in this country and abroad, and was temporarily abandoned because no satisfactory automatic valve existed.



40 r.p.m.



70 r.p.m.

Fig. 17 Indicator Cards taken from Engine shown in Fig. 16

34 European engineers do not hesitate to use large clearance

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[1] Since this paper was written the author has been informed by Mr. Weimer that his company has been using low-lift aluminum valves for the outlet for about ten years and that they are quite successful for speeds up to 60 r.p.m. However, the grinding of the valves is not free from uncertain friction. This fact undoubtedly limits the rotative speed of the engine.

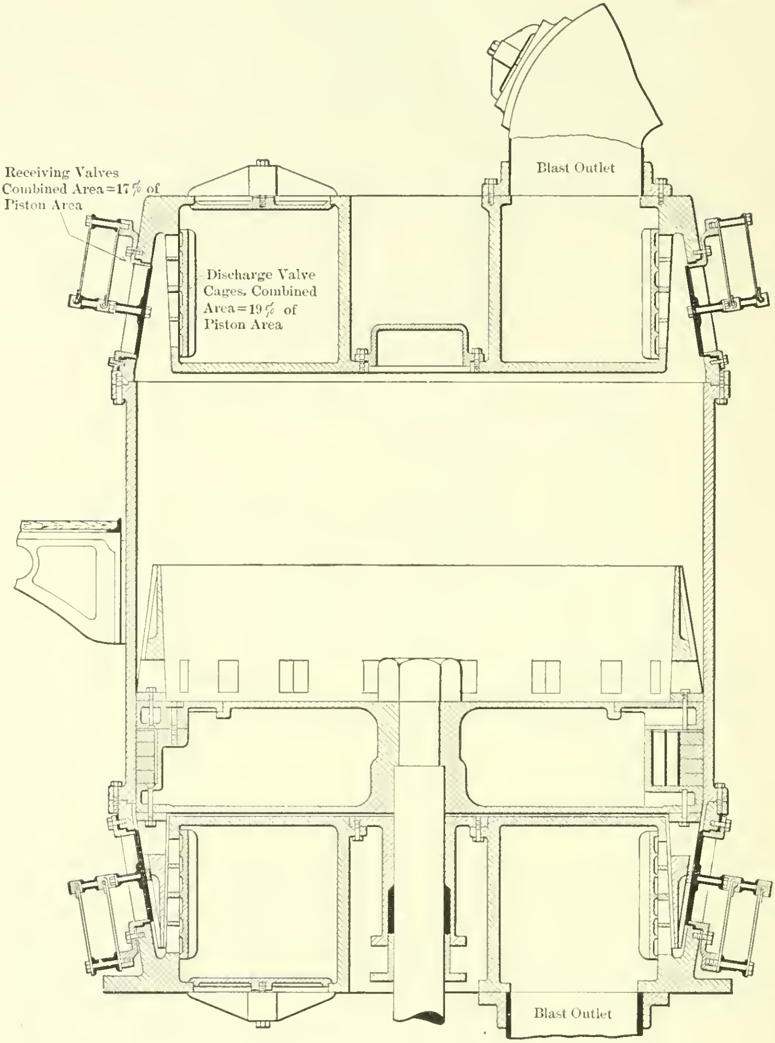


Fig. 18 Engine with Automatic Inlet and Outlet Valves (Weimer)

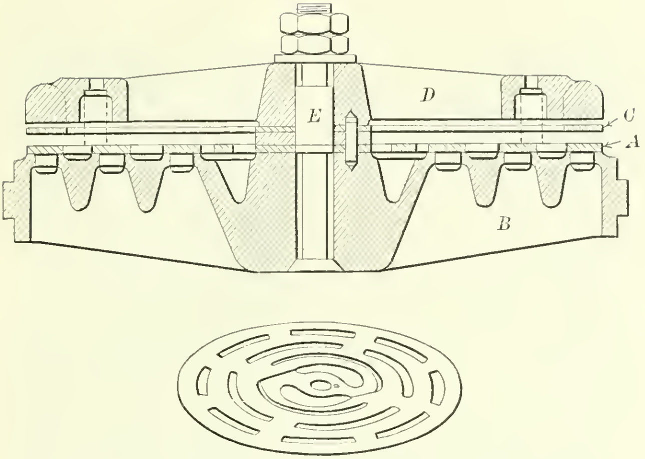


Fig. 19 Multi-Ported Plate Valve (Hoerbiger-Rogler)

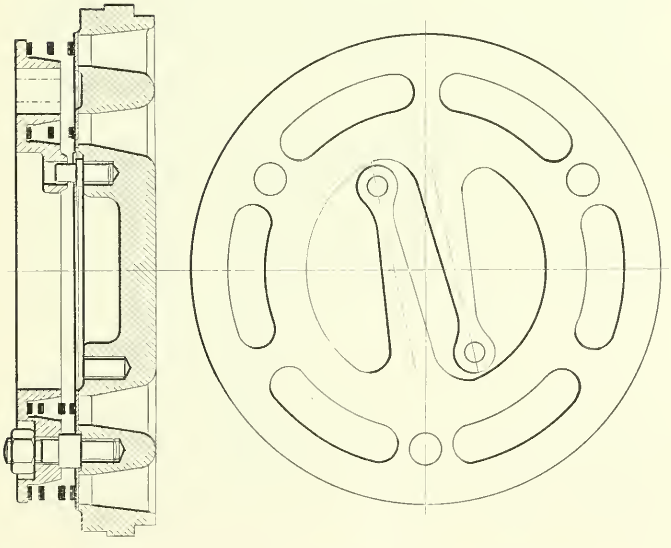


Fig. 20 Multi-Ported Plate Valve (Borsig)

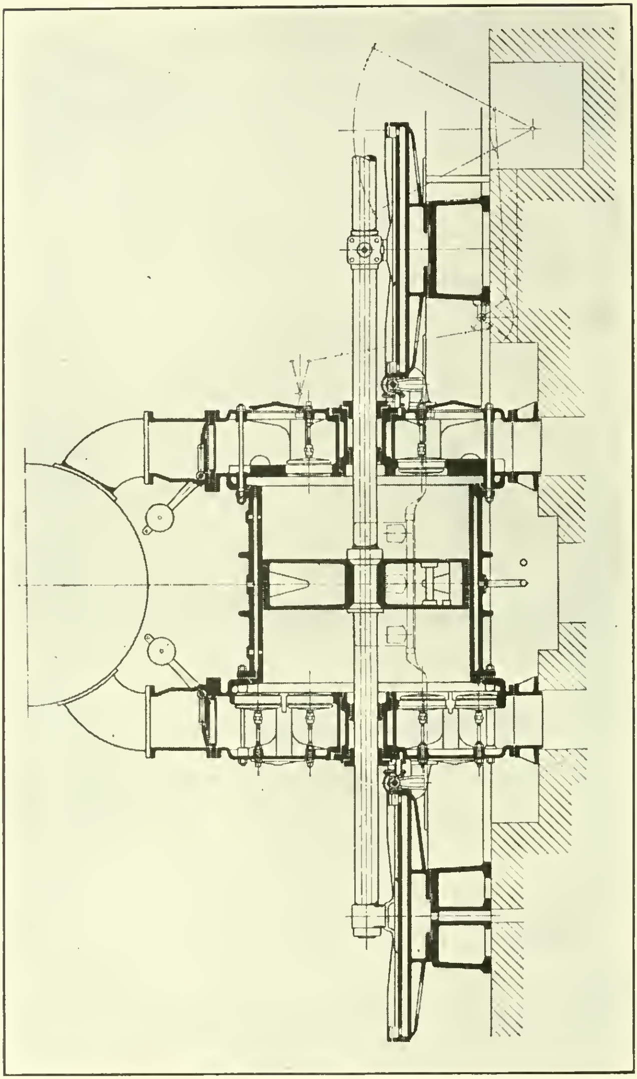


Fig. 21 Blower with Multi-Ported Plate Valves, showing Extended Head

spaces if by doing so other advantages can be gained, and they meet with success. Matters are different in this country. Clearance in a blowing engine seems to be an eyesore to the American furnace man. The influence of this much abused clearance space can be summed up in a few words.

a Clearance volume increases the necessary size of blowing tub for a given weight of air to be pumped per stroke.

b The larger size of blowing tub results in a small increase of friction work and, therefore, in a larger size of power cylinder.

c The influence of the increased heat-exchanging surface on the true volumetric efficiency is small.

35 On the other hand, clearance allows the use of very large valve areas, which fact decreases throttling work and causes better filling of the air cylinder and also allows higher piston speeds, or in other words, a smaller and cheaper engine. The higher piston speed makes possible the use of a more efficient prime mover, namely, the gas engine. When the truth of this is realized, recognition of the merits of the modern European high-speed blower should present no difficulties. The plate valves are so light in weight and the spring load can be made so small that for the greater part of their working time the valves rest against the guard or stop; this fact, of course, greatly reduces fluttering. Furthermore, there are no wearing parts and, therefore, no sliding surfaces nor sticking or binding from gummed and dusty oil. The low lift does not allow the valve to acquire destructive velocity in closing. If a sufficient number of valves are used the pressure loss through the valves is small and the filling of the cylinder is most perfect. The life of the valves is long, provided that they are made of the proper high-grade steel and that the spring loading is properly proportioned. If a valve should break, it can easily be replaced because the valves are light; besides the inlet and outlet valves are alike, so that only a few valves need be carried in stock.

36 To engineers who are accustomed to standard American practice some of the foregoing statements will appear too good to be true and will require proof. Fig. 22 shows an indicator card taken from a Borsig blowing engine in Differdingen. Fig. 23 shows two cards taken at 55 and 82 r.p.m. from a blower with Hoerbiger-Rogler valves in Rombach. This latter card shows the blast pressure in the main just outside the valves, and allows the computation of the valve losses. In Fig. 24 these losses have been plotted

in per cent of the ideal blowing-engine work against piston speed. In the same illustration are shown the valve losses from the Differdingen-Borsig blower computed from detail drawings, and for comparison, the valve losses of a Mesta high-speed blower using cup valves, the results of actual test, are given. The calculation of the Borsig valve losses was based upon the test of the Mesta engine,

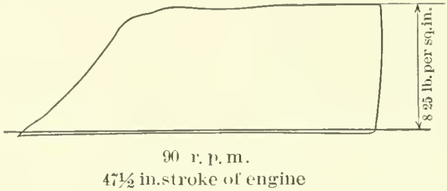


FIG. 22 INDICATOR CARD TAKEN FROM CYLINDER WITH VALVES SHOWN IN FIG. 20

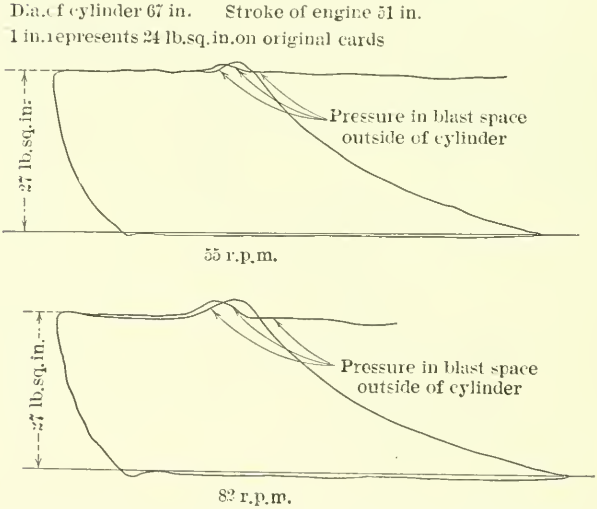
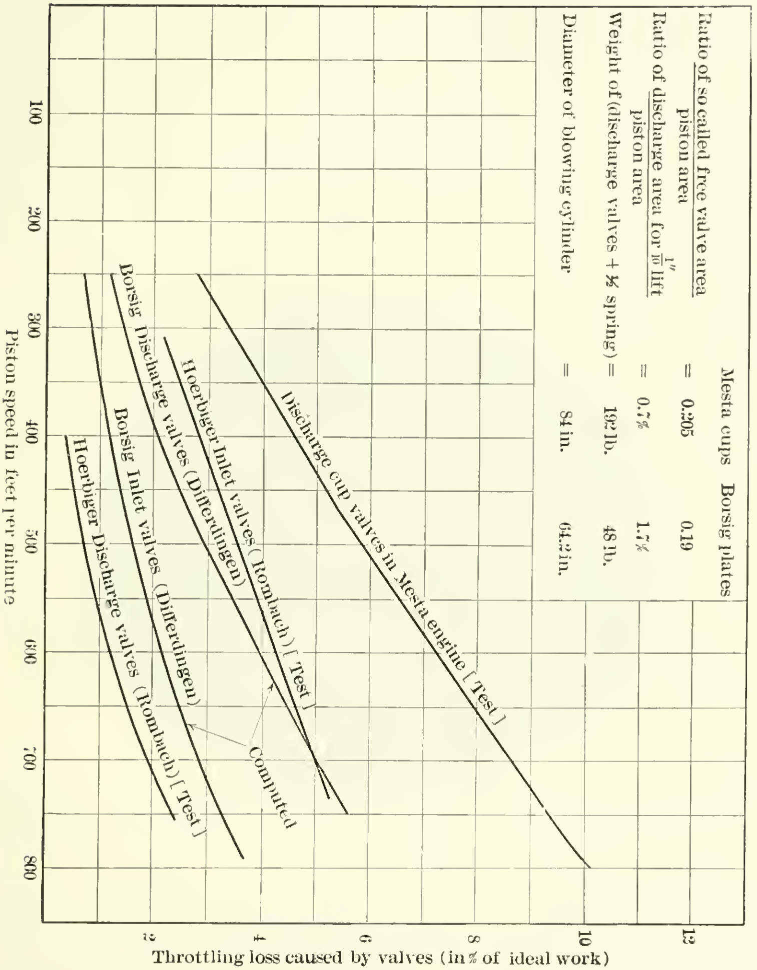


FIG. 23 INDICATOR CARD TAKEN FROM CYLINDER WITH VALVES SHOWN IN FIG. 19

that is to say, the method of figuring valve lifts and losses was checked by a test and the coefficient of discharge was thereby determined. The discrepancy between inlet and outlet losses on the Hoerbiger-Rogler and Borsig valves is entirely due to the respective number



		Mesta cups	Borsig plates
Ratio of $\frac{\text{so called free valve area}}{\text{piston area}}$	=	0.205	0.19
Ratio of $\frac{\text{discharge area for } \frac{1''}{10} \text{ lift}}{\text{piston area}}$	=	0.7%	1.7%
Weight of (discharge valves + $\frac{1}{3}$ spring)	=	192 lb.	48 lb.
Diameter of blowing cylinder	=	84 in.	64.2 in.

FIG 24 THROTTLING LOSS CAUSED BY VARIOUS TYPES OF DISCHARGE VALVES

of valves employed. It will be observed that the plate valves show a very much smaller loss than the cup valves, although the cup valve area is very much larger than standard American practice. Comparison is invited between the engine (Fig. 16) whose discharge valve losses are represented by the chart, and between the engine shown in Fig. 14. The former engine has an 84-in. cylinder bore and ten cup valves of 12-in. diameter. The latter engine has an 80-in. cylinder bore and four cup valves of 18-in. diameter. Since the area exposed per unit lift, say 1-in. lift, counts in a discharge valve, it will be noticed that our American high-speed blowing engines are apparently somewhat inferior to the European type

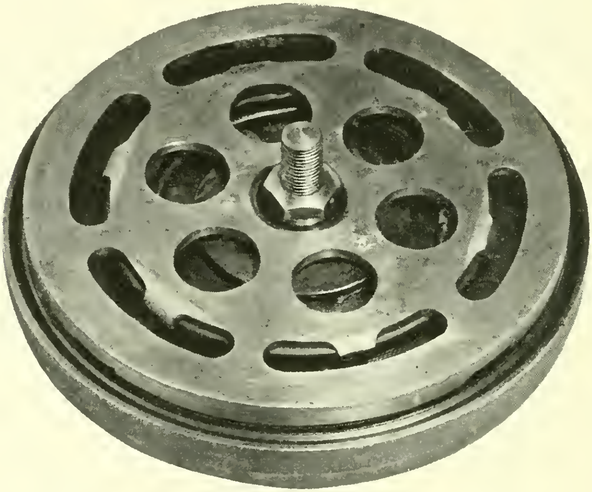


Fig. 25 Multi-Ported Plate Valves (Mesta)

37 With regard to the life of these valves, statements of European builders are interesting. Borsig asserts that in several engines there has not been a single broken valve in spite of continuous high-speed operation, and that in places where valves have broken, this fact could invariably be traced to bad material. Haniel and Lueg, builders of blowers with Hoerbiger-Rogler valves, make exactly the same statement. Particular emphasis is placed upon the almost silent operation of these valves, both by users and builders. No separate cushioning means are employed except that in the Hoer-

biger-Rogler valve an elastic plate softens the impact of the opening stroke before the valve strikes the guard. This cushioning alone does not suffice, but another circumstance comes in helpfully. Thin films of oil coat the valve plate, cushion plate and guard. The squeezing of the air and oil between these plates provides a sufficient cushion to prevent injury to the valve.

38 The author has taken particular pains to secure data on the behavior of valves. Unfortunately, it was impossible to secure such data on the Borsig and Hoerbiger valves with the exception of the indicator cards, Figs. 22 and 23, which, however, are only circumstantial evidence. The author considers himself fortunate in having secured valve behavior diagrams from an experimental engine of the Mesta Machine Company, which has lately begun a series of systematic experiments on a plate valve patterned after those of Hoerbiger and Borsig. This valve, designed by L. Iversen, is intended to equal, or if possible, even surpass the European valves. It will be noted (Fig. 25) that it is guided without friction by a volute spring, flies up against a cushioned guard and is in all respects similar to the above described European valves. Valve motion curves taken from this valve may, therefore, be regarded as indicative of the whole type.

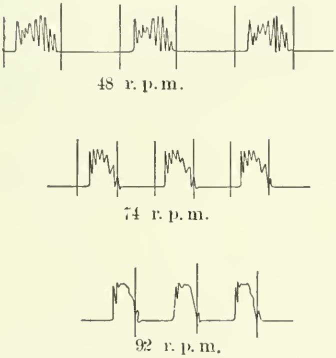


Fig. 26 Valve Motion Diagrams taken from Inlet Valve shown in Fig. 25

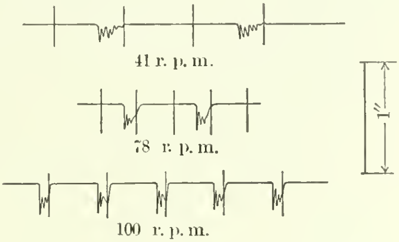


Fig. 27 Valve Motion Diagram taken from Discharge Valve shown in Fig. 25

39 In Fig. 26 the diagrams of the inlet valves are given, and

in Fig. 27 the diagrams of the discharge valve. A standard blowing-engine valve was used, which meant in this case that the valve area was larger than necessary. The result is that the inlet valve flutters somewhat at low rotative speeds and that the discharge valve lifts very little. Besides, the spring load was too great. Allowing for these departures from correct conditions, the curves present enough interesting features. Turning to Fig. 26, it will be noticed that the time of vibration of the valve is practically constant, so that at the high speed the valve has not time to perform a great number of these vibrations per engine stroke; in fact, only one small vibration during lifting and one small vibration during closing occur. At most speeds the valve is closed on the dead center, only at the very highest speeds it rebounds and closes a trifle late. This rebound appears to be caused by a sort of compression wave under the valve, or rarefaction wave above the valve so that the rebound is not necessarily caused by elastic compression of the valve seat. The velocity with which the valve strikes the seat can be determined approximately from the diagrams by the tangent method.

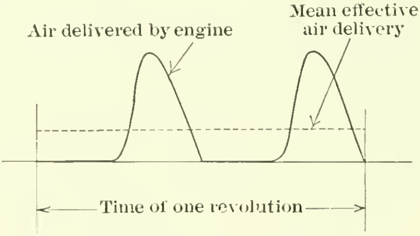


Fig. 28 Air-Wave Pulses caused by Reciprocating Blower

40 From the sound of closing of these valves, the author judged that their velocity of striking must be very much less than those of cup valves in the designs of Figs. 5 and 6. For this reason he was surprised to find from the diagrams (Fig. 26) that the velocity is quite high enough to call for very good material, such as alloy steel. This would be exactly in line with the experience of the German builders who state that unqualified success in these valves is not only a matter of design but just as much a matter of good material.

41 From Fig. 27 it will be observed that the outlet valve is reflected by the cushion plate and is thrown back into the air current, where it duly performs its vibration. At several speeds it closes

late. The air cards, however, show no signs of slip. In spite of the slight delay, the outlet valves close very quietly, as is proved by sound and by the rounding of the diagram at the closing point. The vibrations of this type of valve are of so short a duration that the air in blast mains does not set up synchronous vibrations. The tests on this valve have not yet been finished.

42 From a study of the various types of valves and valve gears, it appears that at the present time the low-lift, alloy steel plate valve promises to become the standard valve for high-speed blowing engines, because (*a*) there is no wear or binding or sticking; (*b*) no lubrication is required; (*c*) it causes very small throttling losses; (*d*) it can be used for the highest speeds; (*e*) it is inexpensive; (*f*) it does away with mechanical gearing, oiling and adjustment.

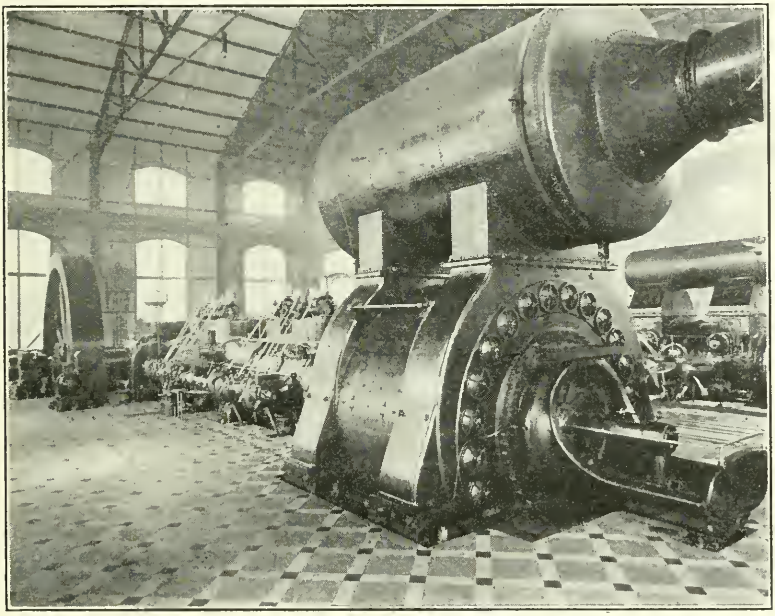


Fig. 29 Blowing Engine with Air Tank on Cylinder

43 No matter with what valves a reciprocating blower is equipped, its delivery remains discontinuous, that is, it delivers air impulses comparable to a constant delivery, over which is superposed a wave motion or vibration (Fig. 28). If the blower discharges directly into the blast main, then vibrations are transmitted with

undiminished strength and shake the whole line. In steam-engine practice this evil was long ago cured by placing a large steam or water separator near the engine, and so convinced are we of the necessity of this separator that we install it also on lines carrying superheated steam, ostensibly for the purpose of dropping out moisture which is not there, but really to damp the vibrations of the pipe line. If a similar request is made of a furnace man for the air line, a great deal of resistance is encountered. The author knows of only one furnace plant in this country where a large tank or equalizer was installed for each blowing engine. The pipe lines thus connected are practically free from vibration.

44 In Europe a similar resistance is probably offered by furnace men; at least it would appear so from the fact that modern high-speed reciprocating blowers are equipped by the builders with large tanks resting on the backs of the cylinders, thus permitting the furnace man to retain his long cherished ideas of pipe-line design (see Fig. 29). The results must be satisfactory, if comparison is made with the American plant in which tanks are used.

45 Summing up, we find that the reciprocating blower has in the last decade made wonderful strides towards becoming a successful high-speed machine. While the increase of piston speed was started by the gas engine as a matter of necessity, it has also benefited the steam-driven blowing engine, and isolated furnace plants can now work with two air cylinders instead of three, because one will successfully blow a furnace in case of emergency, or else three smaller units may be used.

46 The combination of the high-speed reciprocating blower with the blast-furnace gas engine makes the use of the latter profitable even in the Pittsburg district where coal is cheap. The latest group of furnaces in this region has been equipped with slow-speed reciprocating steam-driven blowers. If a high-speed gas-driven blower had been on the market, the result would probably have been different, because then the first cost of the more efficient gas engine would have been lower.

47 A gas-driven blowing engine with 800 to 900 ft. per min. piston speed and high rotative speed will be the most formidable competitor of the turbo-blower, if European experience may be taken as a guide. There are engineers in this country who have already carried into practice higher piston speed for gas engines for electric power, and interesting developments in this line of work may be expected in the next five years.

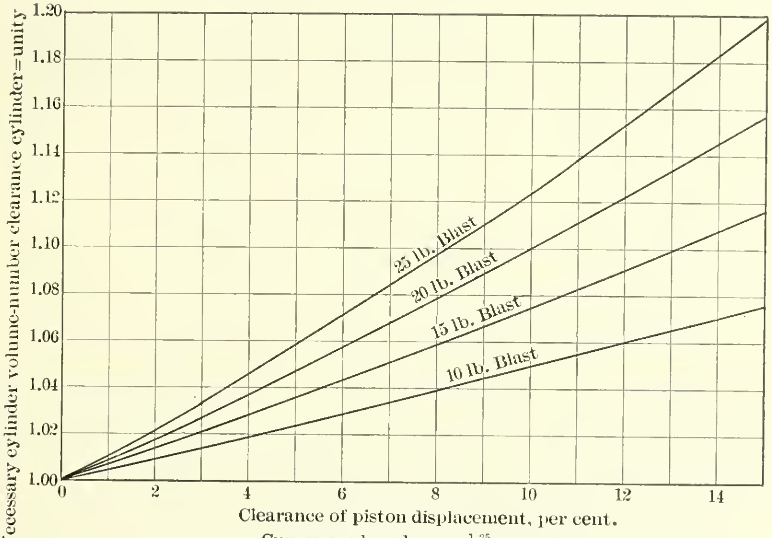
APPENDIX No. 1

THE INFLUENCE OF CLEARANCE (VOLUME AND SURFACE) IN BLOWING ENGINES

48 The influence of clearance is fourfold:

(*a*) The high-pressure air imprisoned in the clearance space re-expands and prevents the entering of atmospheric air until the pressure in the clearance space has dropped down to atmosphere.

(*b*) The surface of the clearance space is heated by the compression, gives up heat to the incoming atmospheric air and thereby reduces the weight of air taken in per stroke.



Curves are based on $pv^{1.35}$ = constant.

Fig. 30 Influence of Volume of Clearance Space Upon Piston Displacement of Blowing Engines

(*c*) The two foregoing actions require a larger cylinder than would be required without clearance space or surface for delivery of a given quantity of air per stroke. The larger cylinder means heavier piston and rod, larger valves; briefly, a more expensive machine for unit weight of air taken in per stroke.

(*d*) The larger parts cause a loss by friction and this fact calls for an increase in the size of the power cylinder, steam or gas.

49 The enlarging of the air cylinder due to the action described under the first heading, re-expansion, can be mathematically determined. The results of such a calculation are plotted in Fig. 30. Since 15 lb. per sq. in. represents the average blast pressure, approximately 1 per cent of increase of cylinder diameter will be necessary for every 3 per cent increase of clearance volume.

50 The influence of clearance surface on weight entering per stroke cannot be mathematically treated, at least not by any formula simple enough for practical use. It should be noted that this harmful surface is present even if the clearance volume is reduced to zero. The lack of knowledge of the influence of the heating surface offers the most assailable point to the opponents of the reciprocating blower. Tests are therefore needed, and the author believes that on an engine with tight valves a thermometer in the intake pipe, a thermometer in the outlet immediately beyond he valves and an indicator will give a very good idea. From the temperature of the outtlet and the shape of the indicator card, the temperature at the beginning of the compression can be computed. Comparison of the value thus obtained with the reading of the thermometer in the intake pipe gives the influence of the walls. From figures on the number of revolutions per pound of coke delivered to the blast furnace and from other data furnished the author by Julian Kennedy of Pittsburg, it appears that the influence of these walls on large size engines is quite small indeed, but no definite conclusions can be drawn, because the reactions in the blast furnace vary.

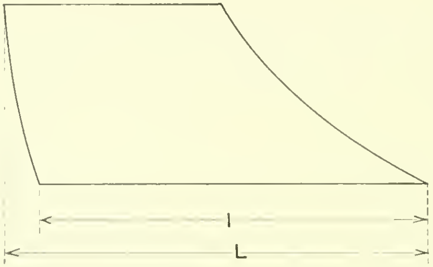


Fig. 32 Theoretical Indicator Card Showing Effect of Clearance

51 The author was particularly interested in variations of volumetric efficiency caused by variations of surface of clearance space. To obtain data on this point, a small 8-in. by 8-in. compressor at the Carnegie Technical Schools was so equipped that its clearance surface could be varied, leaving the clearance volume constant. The quantity of air passing through the compressor was measured by a positive air and water tank displacement meter. Fig. 31 proves that the influence of extra surface is indeed very small, so small as to be of no practical influence in blowing-engine practice. This is reasonable since during the suction stroke the incoming air is exposed to heating by the cylinder head, the piston and approximately one-half of the cylinder barrel in a machine without clearance, and compared to this enormous surface the extra walls of ordinary clearance spaces are small. Besides, heat transmission decreases with diminishing temperature difference, and after the air has been heated a certain amount, further temperature rise becomes sluggish.

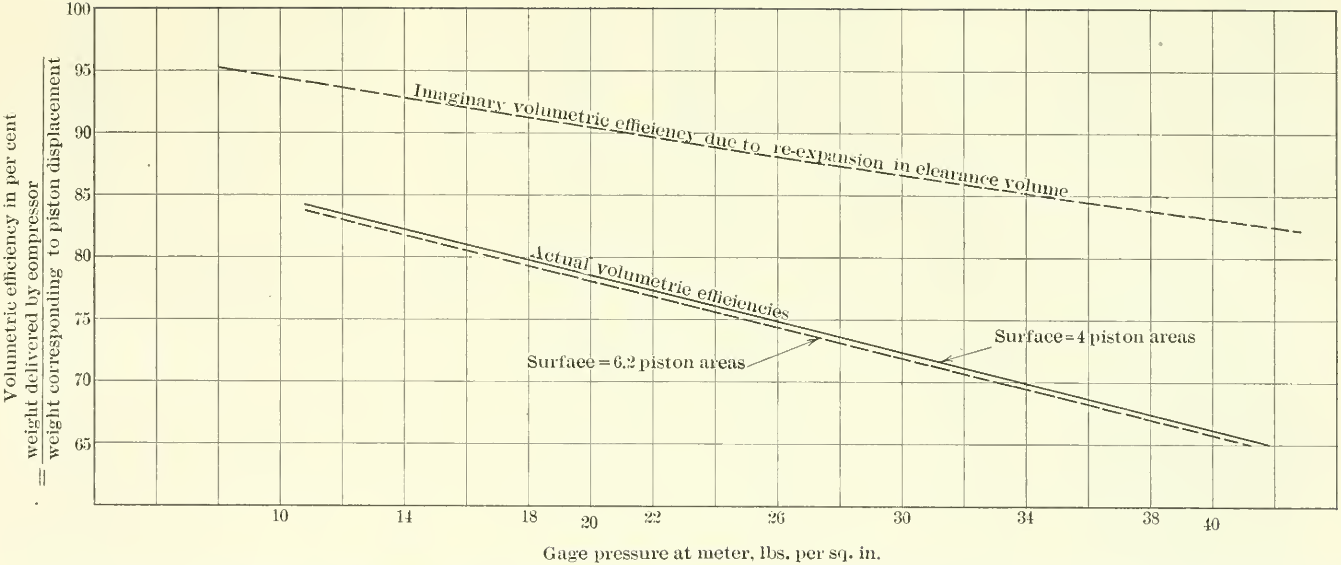


FIG. 31 INFLUENCE OF ADDITIONAL SURFACE IN CLEARANCE SPACE UPON VOLUMETRIC EFFICIENCY. CLEARANCE VOLUME =9.6% OF PISTON DISPLACEMENT

52 It should be noted that in this test conditions were purposely made unfavorable The surface was large compared to the volume; the extra surface was arranged in the current of the air; no radiation from these surfaces to the outside air could take place, and the compression was higher than usual in blowing engines. In view of these facts the statement that the influence of the walls of extra clearance space in blowing engines is negligible will appear justifiable.

53 A brief consideration of (*c*) shows that it is not so serious as might appear at first glance. The larger cylinder is imaginary, because if clearance is enlarged for the purpose of increasing the valve area with a view to allowing higher piston speed the actual cylinder volume per unit quantity of air pumped is much reduced.

54 If, for instance, the rotative speed of an engine is doubled, the ideal cylinder volume per unit weight of air delivered is cut in two; if the clearance is increased a few per cent to accommodate larger valves, the new unit cylinder volume will probably be 52 to 54 per cent of the original one, so that in spite of the theoretical increase of volume, a practical reduction, which is very material, results.

55 The friction loss mentioned under the fourth heading exists in reality and would doom clearance space, if no compensating benefit existed. The magnitude of the friction loss might be determined by tests, but in the absence of tests that cover a sufficient range, the following reasoning is suggested: The mechanical efficiency of blowing engines varies from 85 to 92 per cent, that is to say, the indicated air work is 85 to 92 per cent of the indicated steam work. In order to cover all contingencies, the calculation should be based upon the engine with greatest friction work, that is to say, an engine with 85 per cent mechanical efficiency; the latter figure is equivalent to the statement that 17.6 per cent of the indicated air work is friction loss. Let this figure be correct for an engine without clearance. Then the friction work in an engine with clearance will be greater principally for two reasons:

(*a*) If the stroke remains the same, the forces will be greater in the ratio of $\frac{L}{l}$ (see Fig. 32). Since the diameters of crank pin and of shaft in main bearing are nearly proportional to $\sqrt{\frac{L}{l}}$, the friction path is larger in ratio $\sqrt{\frac{L}{l}}$ for the machine with clearance. The work lost by friction will therefore be proportional to $\left\{\frac{L}{l}\right\}^{1.5}$.

(*b*) Piston area grows proportional to $\frac{L}{l}$, and the piston thickness grows proportional to $\sqrt{\frac{L}{l}}$, so that the piston weight which produces friction grows with $\left\{\frac{L}{l}\right\}^{1.5}$. These figures are based on equal strokes for machines with and without clearance. Friction work from this source, therefore, is also proportional to $\left\{\frac{L}{l}\right\}^{1.5}$.

56 Other friction losses, for instance those caused by crosshead sliding, flywheel windage and others, are not proportional to $\left\{\frac{L}{l}\right\}^{1.5}$, but they certainly do not exceed that ratio.

57 As a first approximation the friction loss may, therefore, be taken as proportional to $\left\{\frac{L}{l}\right\}^{1.5}$ (see Fig. 32). On the basis of a mechanical efficiency of 85 per cent for the no-clearance machine, the additional friction work due to clearance volume has been plotted in Fig. 33. It will immediately be recognized that an increase of clearance volume from 2 per cent to 6 or 8 per cent means a very small loss, a loss that need not be considered, if other more important features can be gained. The most important feature is a smaller and cheaper engine. In steam-driven units this in itself is a gain from the standpoint of the purchaser, provided that 3 or 4 per cent in fuel consumption makes no difference. In gas-engine blowers great fuel economies are made possible, as stated in the main paper.

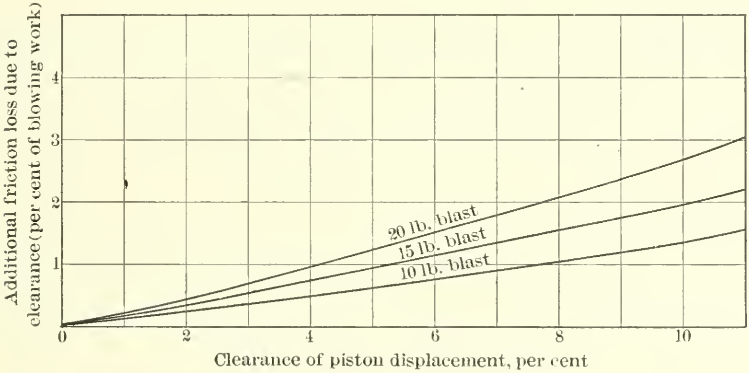


Fig. 33 Additional Friction Loss Due to Clearance in Blowing Engines. Based on 85% Mechanical Efficiency of Engine Without Clearance

POWER FORGING, WITH SPECIAL REFERENCE TO STEAM-HYDRAULIC FORGING PRESSES

By Barthold Gerdau and George Mesta

ABSTRACT OF PAPER

Various methods of producing forgings by power are discussed. Comparison is made between forgings produced by hammers and by presses with regard to quality. The particular fields for power hammers and presses are outlined. The effect of the blow of a hammer and the consumption of steam per working stroke are computed. The various types of presses are discussed with a view of determining their steam consumption under equal conditions. The computation of the steam consumption is carried out. The most interesting features of various steam-hydraulic presses are illustrated.

POWER FORGING, WITH SPECIAL REFERENCE TO STEAM-HYDRAULIC FORGING PRESSES

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Non-Member

George Mesta, Pittsburg, Pa.
Member of the Society

This paper deals principally with the most modern methods of producing forgings, and in order to appreciate these methods it will be necessary briefly to review what has been done.

2 All are acquainted with the fact that the power of the hand hammer is not derived from its weight alone, but from weight combined with velocity imparted by muscular power during a relatively long stroke. The same is true of the sledge and of all sorts of drop hammers, whether lifted by friction, water power or steam.

3 The power of drop hammers depends solely upon the mass of the hammer and its lift; whereas, in a certain kind of hammer operated by steam or compressed air additional power is obtained by increasing the acceleration beyond that caused by gravity alone.

4 While the steam hammer is older than the present generation, this can hardly be said of the modern type of forging press, illustrated diagrammatically in Fig. 1. A plunger *a* is forced by hydraulic pressure against the forging *b*, thus exerting a steady pressure instead of a blow. All forces are self-contained and no free forces are transmitted to the foundation.

5 In the course of events the forging press began to supplant large steam hammers everywhere, whereas the small hammer, operated by steam or compressed air, has held its own for small work. In the authors' opinion, the logical reason for this fact is the following: Small pieces cool quickly and, as a rule, require a finer surface finish than is demanded in large forgings. Since the hammer strikes

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

a blow, the force of the impact increases as the forging cools, so that work is done on the surface of the forging, even when it is quite cool. The press, on the other hand, would be powerless to do any work on the cold piece, unless the anvil surface was reduced very much.

6 Thus the hammer will probably always be used for small work and for making tools, because tool steel must not be heated as much as machinery steel or wrought iron.

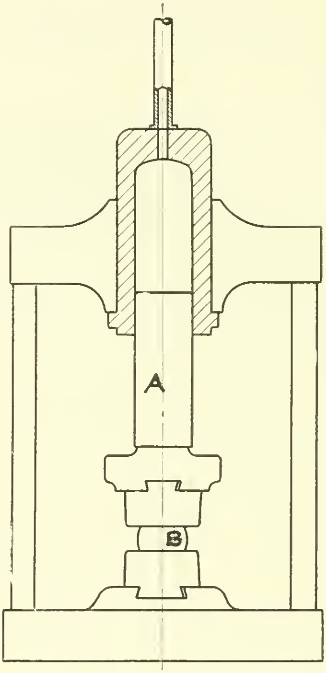

Fig. 1 Simple Type of Forging Press

7 The very features which make the hammer desirable for small work make it undesirable for large work. The hammer acts upon the surface of the material, driving the surface over the core without compressing the latter, as in Fig. 2. The press, on the other hand, exerts a continuous pressure, which forces the semi-fluid material of the forging to flow under compression, as in Fig. 3, which process tends to increase the density of the material.

8 It is thus evident that from the standpoint of improving the quality of material of forgings, the press is superior to the hammer, and it would be considered even more useful if, under equal conditions, it used less steam than a hammer would consume.

9 To investigate the comparative steam consumption, a concrete case will be assumed. Let the dimensions of a hammer with live steam above the piston be as follows:

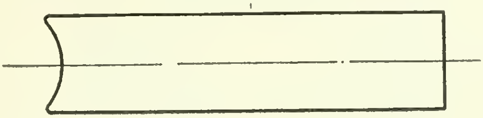

FIG. 2. SHOWING EFFECT OF HAMMERING

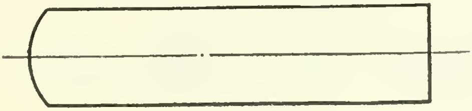

FIG. 3. SHOWING EFFECT OF FORGING BY PRESSURE.

Weights of falling parts $P = 5$ long tons
Diameter of steam cylinder $= 27\frac{1}{2}$ in.*
Stroke of piston = 79 in.
Initial steam pressure = 107 lb. per sq. in.
Mean effective pressure = 71 lb. per sq. in.
Face area of anvil = 186 sq. in.

Then we find :

a Mean effective accelerating force (P_2) due to steam pressure =

$$\frac{\pi}{4} \times 27.5^2 \times 71 = 42{,}000 \text{ lb.}$$

b Acceleration provided by P and P_2 =

$$\frac{(42{,}000 + 11{,}200)\ 32.2}{11{,}000} = 155 \text{ ft. per sec.}$$

c Velocity (V) of moving parts at end of stroke =

$$\sqrt{2 \times \text{acceleration} \times \text{stroke}} = 45 \text{ ft. per sec.}$$

d Kinetic energy stored up in moving parts =

$$53{,}200 \text{ lb.} \times \frac{79}{12} \text{ ft.} = 350{,}000 \text{ ft-lb.}$$

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* These dimensions were converted from metric dimensions, which accounts for the odd sizes.

For hammers of this size and correct temperature of forging, it may be assumed that the moving masses are brought to rest within a space of $1\frac{5}{8}$ in.

e Basing the retardation of the moving parts upon this distance the average retarding force is found to be 2,580,000 lb., or approximately 1200 long tons. This figure may be termed the force of the blow and will be used below for comparison with a press. This force was based upon a retardation space of $1\frac{5}{8}$ in. It would be wrong to assume that all of this space is utilized for compressing the forging. The elasticity of the foundations absorbs a considerable amount of the work of the blow. A correct mathematical treatise of these losses meets with insurmountable difficulties. From the experience of the authors it appears that almost one-third of the work is lost in vibrations so that only about 1 in. of useful compression or deformation of the forging results.

f Since it is intended to investigate the relative economy of different methods of forging, the steam consumption per working stroke of the hammer in question will now be computed. Steam is needed for the lifting and for the down-stroke. The steam for the up-stroke may be figured approximately from the equation that pressure multiplied by change of volume equals work done. Thus cubic feet of steam required for up-stroke=

$$\frac{11{,}200\times\frac{79}{12}\text{ft-lb.}}{144\times107\text{ lb. per sq. ft.}}=4.8\text{ cu. ft.}=1.3\text{ lb.}$$

10 For the down-stroke a cylinder full of steam at 71 lb. per sq. in. pressure may be taken, which will be sufficiently close for this purpose. Thus the volume of the steam per down-stroke=

$$\frac{\frac{\pi}{4}\times27.5^2\times79}{144\times12}=27\text{ cu. ft.}=5.4\text{ lb.}$$

The steam consumption of one cycle then equals 6.7 lb.

11 This steam consumption is based upon correct operation of the hammer, which, however, is seldom realized if the operator neglects to close the throttle at the instant the hammer touches the forging, because in that case the pressure in the cylinder may rise to

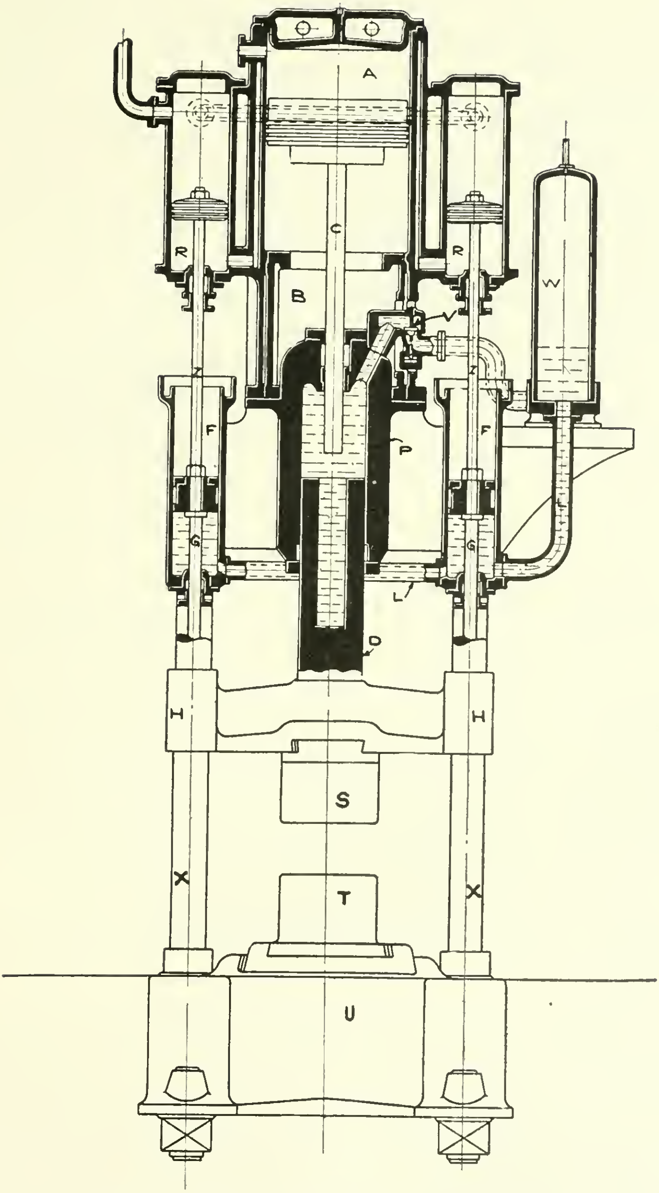

Fig. 4. Steam-Hydraulic Forging Press

boiler pressure. If the hammer is used to strike light blows, full strokes may be made, using the hammer principally as gravity drop, or short strokes may be made with live steam on top. In either case the steam consumption per unit of work done is enormously increased. The great number of combinations possible forbids giving figures.

12 Turning to the steam consumption of the press, we find that conditions are not so simple. It will be remembered from Fig. 1 that the press is operated by water under pressure. The steam consumption then depends first upon the method of producing the water pressure and second upon losses of water pressure between its production and its application to the press plunger.

13 Before the intended computation can be made, it is evidently necessary to review the various types of presses on the market. Two general types of presses exist: (*a*) The so-called purely hydraulic presses whose pressure-water is furnished by separate pumping engines; (*b*) the so-called steam-hydraulic presses in which water under pressure is generated in a steam intensifier.

14 The general type mentioned under (*a*) is best illustrated by Fig. 1; the pipe at the top of the cylinder is connected either directly or by means of a hydraulic accumulator to a high-pressure pump which may be either direct-acting or of the crank flywheel type.

15 The type mentioned under (*b*) is shown diagrammatically in Fig. 4. The press consists of a heavy base *U* and four uprights *XX*, supporting the hydraulic and steam cylinders above. *S* and *T* are the dies, the upper one being carried by the crosshead *H*. This crosshead is moved into position for forging by the use of the steam cylinders *RR*. Pressure for forging is obtained by admission of steam into the top of cylinder *A*, which moves the piston downward and forces rod *C* into the hydraulic cylinder *P*. This action again causes the plunger *D* to move downward, carrying with it the crosshead and the upper die. The effect is that of a steam-actuated intensifier.

16 Hydraulic cylinder *P*, balancing cylinders *FF* and about one-third of air chamber *W* are filled with water. Air pressure of about 100 lb. is pumped into air chamber *W*, which is sufficient to move piston rod *C* with its piston to the top of steam cylinder. The areas of plunger *D* and cylinders *FF* are equal, so that the downward force on plunger *D*, due to the air pressure on the water, is counterbalanced by cylinders *FF*. By opening check valve *V* in the connection between air chamber *W* and hydraulic cylinder *P* thus, allowing water to flow from the hydraulic cylinder to the air chamber,

and admitting steam to cylinders *RR*, the crosshead can be raised to any position and similarly it can be lowered.

17 Referring to type (*a*) it is found that the pumps commonly work against a pressure of 4300 lb. per sq. in. which is maintained by an accumulator. Unfortunately, the process of forging does not always require all of this pressure, but on the average only about 50 to 60 per cent of this amount, the remaining 40 to 50 per cent being lost in the controlling valve.

18 It might appear that it would be more economical to let the pump work directly against the press without an accumulator and even without intermediate controlling valves, but this scheme is too ideal to be practical. It has been found necessary to provide controlling valves, by-pass valves, throttling governors and other means for regulating the speed and power of the press.

19 Nevertheless, this type of press has one advantage, namely, that it can make a continuous full-pressure stroke of the maximum length for which the press was built. For this reason this type is most advantageous for drawing operations, for instance, the drawing of tubes, etc.

20 Taking up type (*b*) as illustrated by Fig. 4, it has already been mentioned that the pressure is generated by a direct-acting intensifier which is similar in its action to a direct-acting pump. While at first thought it might appear that the direct-acting intensifier, which necessarily has to maintain an almost constant steam pressure throughout the stroke, would be inferior to a high-class compound crank and flywheel pump, experience has taught that the opposite is the case, the reason being that the work is intermittent and requires a continually varying amount of power.

21 After these explanations we are ready to take up the computation of the steam consumption of a press for the same work which formed the basis for a similar calculation for the steam hammer. From what has been said it is evident that the type of pump, the conditions under which it works, the proper balancing of the accumulator pressure with regard to the work and other factors, affect the steam consumption. Therefore the following figures should be considered only as an attempt to solve the problem.

22 The effective work of the hammer was 240,000 ft-lb. per working stroke. Basing the press on the same work and taking the efficiency of the transmission pipe as 90 per cent, the pressure drop in pump ports as 10 per cent, and the efficiency of the pump as 75 per cent, the work actually to be done in the pump

cylinder is 395,000 ft-lb. Let the pump be driven by a steam engine whose steam consumption is 32 lb. per hp-hr. on account of the intermittent working; then the steam required for the equivalent work is

$$\frac{395{,}000\times32}{33{,}000\times60}=6.3 \text{ lb.}$$

This shows that the purely hydraulic press is slightly more economical than the steam hammer.

23 Matters are a great deal simpler for the direct-acting steam-hydraulic press. Basing the calculation upon the fact that pressure, times change of volume equals work, and assuming a steam pressure of 150 lb. per sq. in. gage, we find the necessary volume of steam to be

$$\frac{240{,}000}{150\times144}=11 \text{ cu. ft. or } 3.7 \text{ lb. of steam}$$

For the sake of simplicity friction of pistons has been neglected in all cases. This last result is reliable, whereas in the case of the purely hydraulic press and in the steam hammer, additional losses may occur which cannot very well be considered on account of their uncertainty. The excellent economy of the direct-acting steam hydraulic press presupposes that no dead volume of clearance space has to be filled before the motion of the steam piston against its full resistance begins.

24 The importance of this last sentence is so great that the authors take the liberty of repeating it in different words. The expression used actually includes three separate facts: (*a*) The steam piston of the intensifier must be in its starting position with practically no clearance; (*b*) the movable anvil must practically rest on the piece to be forged; (*c*) there must be no voids in the plunger-and-intensifier cylinder.

25 These three principles are embodied in the design shown in Fig. 4, which, in the authors' opinion, represents the most practical form which this type of press can assume. In this system the formation of voids in the water space is impossible, because the intensifier plunger floats upon the water at all times; in other words, the direction of motion of the intensifier piston and plunger is the same, which thus provides a continual force closure. If such force closure were absent, and in some types of steam hydraulic presses it actually is, there would be no guarantee of a filled water space and increase of steam consumption would be the inevitable result. Moreover, it will be seen from Fig. 4 that the pressure is generated directly

in the same cylinder in which it is used, thus avoiding the losses which must occur where the intensifier is separated from the press itself and the pressure water has to be forced through pipes and connections.

THE MECHANICAL ENGINEER AND PREVENTION OF ACCIDENTS

BY JOHN CALDER, PUBLISHED IN THE JOURNAL FOR FEBRUARY 1911

ABSTRACT OF PAPER

The paper discusses the nature and incidents of industrial injury, its prevalence and high rate, in the United States in particular, and the present general desire for better conditions of safety. It analyzes the chief causes of injury as revealed from a study by the author of a large number of verified casualties and recommends practicable measures calculated to reduce the present numerous fatalities and injuries. It discusses in particular the important services which the mechanical engineer, both as an executive and as a constructor, can render in exercising his ingenuity to avoid industrial accident.

The paper contains a number of practical safeguarding illustrations from the field of machine building, equipment installation, transmission plant and especially dangerous machines and processes, and concludes with suggestions for administrative and remedial precautions.

DISCUSSION

F. R. HUTTON. The protection of working people from disaster is primarily the job of the mechanical engineer; whether the mechanical engineer is regarded as the designer of the individual tool by which specific production is carried on, or whether in a larger sense the mechanical engineer is regarded as the designer of the works in which, as a tool, production as a whole is carried on. The analysis with which Mr. Calder has underlain his discussion presents to you in the form in which it has presented itself to me, albeit a little different from his, the philosophy of the origin of accidents.

If there is no power in a plant, there will be no accident. The aphorism of the wise German philosopher, who said, "Show me a man who never made any mistakes, and I will show you a man who never did anything," has its parallel in the safety field—show me the works in which there are no industrial accidents, and I will show you

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, 29 West 39th Street, New York. All discussion is subject to revision.

works in which they nowhere turn a wheel. The mere presence of great dynamic power concentrated in a factory, which is so much greater than the possible resistance of the strongest human body, means that the man exposed to a blow from dynamic power goes under. If that dynamic power ever gets beyond control, there is an accident, and no thinking, no planning in advance by the mechanical engineer can prevent such accidents. It is therefore obvious that the starting point of all accidents is the power. And in preparing the scheme which is to underlie the exhibit of a well-ordered Museum of Safety,[1] the starting point, the first class, will be the power plant accidents and the prevention of such accidents; the second, the transmissive machinery accidents; the third, the accidents at the danger zone of the tool, and the fourth, the accidents which happen in the plant anywhere independent of the danger zone of the tool.

When we begin to consider the problems in the danger zone of the tool itself, the very magnitude of the field begins to appall. There is no limit to the possibility of the dangerous accidents which can happen in the danger zone of the tool, if the word tool is used in its widest sense. A mine may not be thought of as a tool, but it is. It is an apparatus destined and designed for production. Exhibits from the American Museum of Safety both emphasize what Mr. Calder has said in some directions, and amplify it in others. One of the best things Mr. Calder brought out—and he threw it off as if it were a mere trifle—was that there is no use of signs. The man who will present a sign or symbol for danger which shall be as clearly understood as the cross is in the religious world will be one of our great benefactors. What we want is something that will signify that here is a danger point, not specifically saying "Look out for death," but here is a place at which danger lurks.

The United States Steel Corporation have an emphatic sign for a death danger in the form of a skull and cross bones. For the danger of electricity, they have a closed hand, the hand of Jove, with the thunderbolts going in all directions. The difficulty met with in so many places in this country is that no sign whatever, unless given in eight languages, is of any use. The sign in English might serve for many, but you must repeat it eight times. The skull and cross bones is open further to the objection that its effect is so intense that by and by it fails to attract attention. The death's head overdoes it. No-body quite likes to show the red flag, which is up to date the best suggestion that has been offered. That unfortunately now has a double significance in some parts of the country, and yet, it would be a splendid warning note for the purpose: to say "Look out for yourselves."

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[1] The American Museum of Safety, 29 West 39th Street, New York, maintained by the Industrial Safety Association.

Among the accident-preventing devices there are two very interesting types of what may be called the interlocking system of safeguarding. The philosophy of that as applied to a punch or press is that the operator has to work two levers, one with his right hand and the other with his left. He can not operate the machine and have his fingers anywhere in the danger zone. Nothing could be better than that as an ideal design, from the mechanical engineer's point of view as a safeguard, but it is prohibitive on the economic side. You have at once removed the possibility of the operator doing as much in an hour as if he had one hand free or both hands free.

What Mr. Calder has to say about wood-working machinery is very much to the point. There is a device offered where the operator stands upon a rubber mat, making it reasonably impossible for him to fall against the saw. The tale of the man falling against a revolving circular saw told by Mr. Calder is no exaggeration.

Mr. Calder has referred with great emphasis to the difficulty of having safety recommendations carried out. The method which has been followed in the United States Steel Corporation through its various works is to create at the individual works committees of safety of the men themselves. Usually, the foreman is the chairman of the committee of safety in that department and associated with him are those in the group of workmen themselves whose business it it to see that everybody keeps his safety devices about the plant in condition and in use. It makes the men themselves responsible for the maintenance of the safety provision and responsive to suggestions as to where increased safety can be procured, and unites the employees in bringing about this point of common safety, to secure which no better method has been found.

Byron Cummings. For our purpose this subject may be considered under three heads:

a Is it possible to reduce the number of industrial accidents without reducing the output?

b Will it pay employers to adopt methods of operation and safeguarding necessary to produce the desired result?

c What measures are best calculated to produce the desired result?

As to the possibility of preventing accidents the testimony of those who have adopted a systematic plan for that purpose warrants the opinion that a very large proportion of industrial accidents are preventable.

Mr. Calder cites one plant in which the annual number of accidents was reduced 68 per cent. He states that this experience has been repeated in many cases. The Edison Electric Company report that the result of their efforts for accident prevention has been very satisfactory, and the United States Steel Corporation state that preventive measures adopted by them have reduced the annual number of accidents by 50 per cent. Furthermore it is admitted by authorities that practically 50 per cent of the industrial accidents in this country are preventable accidents.

To the second question, Will it pay to employ the necessary preventive means, we think there can be but one answer and that is, it will, to which the testimony of all who have employed such measures subscribes.

In considering this phase of the question we desire to call attention to the attitude of the courts with reference to claims for damages on account of industrial accidents. If the claimant can show that the accident was due to unguarded machinery of any description, it is more than probable, if the injury was serious, that judgment in his favor will be rendered for an amount considerably in excess of $5000, the usual limit in a liability policy for an accident to one person. It matters little if it be contended that the appliance that caused the accident was one not usually guarded, or that it was in an out-of-the-way place, or that it was not dangerous; the fact that the accident was due to the absence of a guard is accepted as prima facie evidence that the machine, appliance belt or condition that caused the accident was dangerous and should have been guarded. Comparatively recent judgments have been rendered for $15,000 for injury that caused the loss of a leg; $25,000 for the loss of four fingers in a laundry accident; $30,000 for the loss of one hand and part of the other in a printing office; $7500 for the loss of one leg; $11,000 for the loss of five toes; $12,500 for the loss of sight; $17,500 for the loss of an arm, and $27,500 for the loss of an arm and a foot. We do not wish to be understood as claiming that as heavy judgments as these are usual, but they are becoming alarmingly frequent—their frequency being emphasized by the fact that during a period of three months, 31 personal injury cases were decided by the Minnesota Supreme Court confirming judgments of $144,926 and reversing judgments to the amount only of $6600.

We have no details as to the number of verdicts affirmed, but assuming that only 10 per cent of the verdicts were reversed, we have judgments confirmed in 90 per cent of the cases acted upon averaging over $5000 each. The State of Minnesota is not alone in this matter. The laws of many of the leading manufacturing States are very similar and the decisions of the courts in any one State generally follow closely the decisions in others. Moreover the state of public opinion is such that more stringent laws are continually being proposed, there being at the present time under consideration in the various state legislatures no less than 21 employers' liability and workmen's compensation laws, some of them being more exacting in their demands than anything heretofore proposed in this country.

When considering the advisabilty of installing safeguards the employer should not overlook the fact that the absence of a guard may entail a heavy loss similar to those above noted. He should also take note of the fact that the Supreme Court of Michigan has decided that failure of a state factory inspector to recommend a guard is not a valid defense on account of an accident due to the absence of a guard.

For the reasons given and for many others that could be cited, we believe that we are justified in the opinion that as a matter of business policy it will pay the employers to use every possible method and appliance for the prevention of industrial accidents.

At this point, we wish to call attention to what may be termed elevator hazards. The author's statement with reference to this hazard may lead some persons to think that the dangers in elevator operation have been eliminated, but such is not the fact, for 193 elevator accidents are reported in two years in hotels and apartment houses, of which 53, or more than 25 per cent, were fatal. It is true that efficient safeguards have been provided for passenger elevators but, nevertheless, entirely too many elevator accidents are happening. Careless operation is responsible for many of these accidents but carelessness or negligence on the part of passengers is also responsible in a number of cases. Probably 50 per cent of the number of accidents on passenger elevators are due to passengers attempting to enter or leave the elevator when the elevator is in motion or to some other condition in connection with the entrances to the hoistway due to improperly guarded hoistways. The use of efficient interlocking doors on all passenger elevators and the proper safeguarding of the entrances to hoistways on freight elevators would prevent a large number of accidents annually.

While on the subject of hotel accidents, we wish to call your attention to the number of dangerous machines employed in an up-to-date hotel. The laundry, usually conducted on the hotel premises, contains the dangerous mangle and the centrifugal dryer. Much of the danger in connection with these machines may be eliminated by the use of the latest improved safety device but there are far too many old types of inefficiently guarded machines still in use. Another attribute of the hotel is the dangerous steam cooker, not the original steam jacketed kettle but the cooker in which live steam is turned directly into the chamber in which the food is to be cooked. Many very serious accidents caused by escaping steam when opening the doors of these cookers have occurred. Such accidents may be prevented by the device which will make sure the passage of steam from the cooking apartment before the door can be opened.

We all know the dangers of the circular saw, but an up-to-date hotel has a machine called an ice cuber which has usually five circular saws in one machine, this being used to cut the ice into the small cubes which are placed in the glasses of the guests. Machines of quite recent manufacture have these saws guarded, but there are many in use without any guarding whatsoever. When in addition to the circular saw hazard we have a hazard due to wet floors caused by the melting ice, we have an extremely dangerous condition, which should be eliminated by the use of the latest guarding appliance and corrugated rubber covering for the floor surrounding the machine.

In considering the methods best calculated to prevent accidents, the use of caution notices should be mentioned. The author states and we agree with him that the ordinary caution notice is of doubtful efficiency. There is, however, a type of notice coming into use which we believe will assist in preventing accidents. This notice consists in the statement of the employer that he desires to prevent accidents whenever possible and requesting the coöperation of his employees and suggestions from them as to methods or appliances calculated to bring about the desired result. One of these notices in use by the Minneapolis Steel and Machinery Company is as follows:

DANGEROUS

Notice to Employees to Prevent Accidents

This machine is dangerous and cannot be guarded. Unusual care is required to operate it safely; and no one should operate it without having had full instructions from the foreman.

This notice is posted in order to comply with the following Labor Law of the State of Missouri:

Extract from Section No. 6433: The belting, shafting, gearing and drums, in all manufacturing establishments when so placed as to be dangerous shall be safely and securely guarded when possible; if not possible, then notice of its danger shall be conspicuously posted in such establishments.

Another used by a company operating a number of breweries in Ohio goes farther and promises a money reward for practical suggestions that have been adopted.

NOTICE TO EMPLOYEES

It is hereby expressly made the duty of each employee to report at once to the foreman in this plant, and also to the president or secretary of the company at its main office, any defective or unsafe condition of the grounds, buildings, machinery, tools or appliances, lack of guards or the improper operation of any machinery in or connected with the plant, and, under no circumstances to continue to operate or use the same before the defect is remedied, and he is strictly forbidden to clean, oil, handle or repair any machinery while it is in motion.

This rule must be enforced, and failure to comply therewith will be sufficient grounds for suspension or discharge.

The company welcomes any suggestion which employees may make for guarding their safety, and will pay for such suggestions as it may adopt.

The Cleveland and Sandusky Brewing Company

December 15, 1910.

We believe that notices along the above lines will accomplish much good, but in our opinion the best method for the prevention of accidents of which we have any knowledge is that adopted by the United States Steel Corporation and consists in what may be termed inspection committees or committees of safety. The South Chicago Works have given careful and earnest attention to this matter and we believe that if similar plans are adopted and carried out earnestly and concientiously by mechanical engineers in charge of large operations that the result cannot help but be beneficial. Some of the rules at the plant referred to are as follows:

FACTORIES, SHOPS AND YARDS

General Instructions to Foremen

No. 1 Have a thorough understanding of the following rules. Until you know them all, and are living up to them, you are not doing your duty.

No. 2 You will be held responsible for accidents to your men or to the public.

No. 3 You should caution your sub-foreman regarding the prevention of accidents, but you will still be responsible for your sub-foreman.

No. 4 Watch out for men who are hurt frequently, either by carelessness or bad luck and put them where they will not get hurt.

No. 5 You must not put men to work on any job until you have inspected everything and satisfied yourself that the place is safe; you must warn men of any danger that may come up in the course of doing this work. If on returning after you have been away, you see a man violating your instructions or taking chances that place him liable to injury, deal with that man so as to make it certain he will not again disobey orders.

No. 6 Judgment should be used at all times in placing men on jobs; heavy, slow men should not be placed on jobs where a light, quick man is required. Slow thinking, unintelligent men should not be placed around machinery or in places where presence of mind is required, for by so doing the probability of accidents is increased many times.

No. 7 One or more workmen should be chosen to act in each division as an inspection committee to serve one month each. Each member of this committee to spend one day each week inspecting his division; making four inspections by each committeeman each month, and he shall report his findings and suggestions to his foreman after each inspection. After their term on the committee expires, the men who have served are urged to continue looking for dangerous places or dangerous customs or dangerous conditions in their division and to report the same to their foremen. In the course of time it is hoped that a large proportion of the employees will be actively looking for dangerous places, customs or conditions. Every man appointed on this committee should be taught that his duty is a most important one; that he is not a spy but that he is a safety inspector; that he is doing his duty when he points out dangerous places, or dangerous conditions or a dangerous custom, and by so doing he is protecting the life and limb, not only of himself, but of his fellow workmen in the plant.

The success of the United States Steel Corporation in the matter of prevention of accidents is evidence that the methods they have pursued have been effective and are worthy of the attention of every mechanical engineer interested in the matter.

L. D. Burlingame. I believe it will be of value as illustrating and emphasizing what Mr. Calder has so well outlined, to present some specific illustrations of what has been done in the line of safeguarding and sanitation by the Brown & Sharpe Manufacturing Company, who for many years have given much attention to such matters.

Taking first the feature of cleanliness and light, Fig. 53 shows a corner of the polishing department, often one of the dirtiest and most unhealthful places to be found about a shop. This view indicates the the light, airy condition of the room, in addition to which exhaust pipes are connected with every polishing stand, carrying the dust entirely out of the room. Guards are provided for the wheels and chairs for the comfort of the workmen. At the end of each line of shafting is a rail to guard against a workman's falling accidentally on the moving parts.

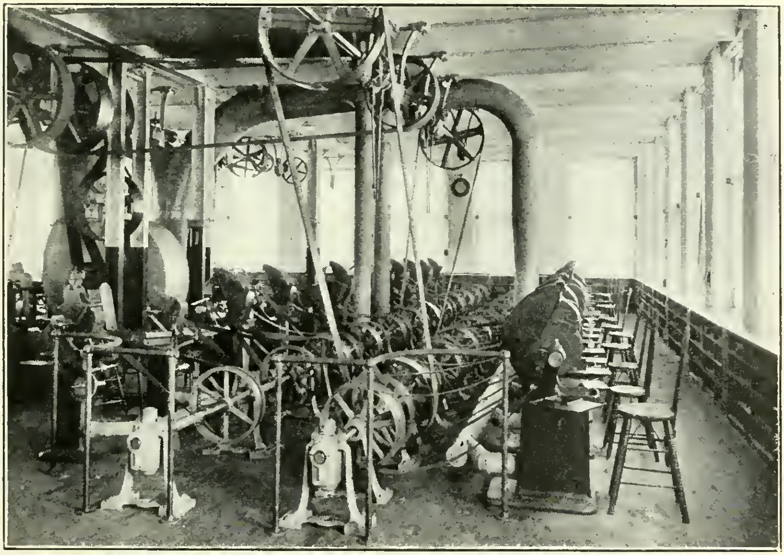

Fig. 53 Polishing Room, Brown & Sharpe Manufacturing Company

The Evolution of Gear Guards. Fig. 54 shows a design of manufacturing milling machine of an obsolete type in which the guard only partially covers the gears, leaving an element of danger which has been entirely remedied in the later design of machine shown in Fig. 55, where the gears are completely encased.

Fig. 56 shows a constant-speed drive milling machine with all gears inside, these being controlled and adjusted by levers from without.

The chain from the motor is also fully guarded. These last two views are illustrative of the present trend in machine tool design where safeguarding features are included as a part of the design of the machine.

Experience has shown that with machines where the gears are not completely encased, many accidents are prevented by the wearing of short sleeves, and their use is compulsory in these works for apprentices, as shown in Fig. 57. A case where gears are exposed on an old design of gear-cutting machine and where a temporary wooden guard is used to form a partition separating them from the passageway is shown in Fig. 58.

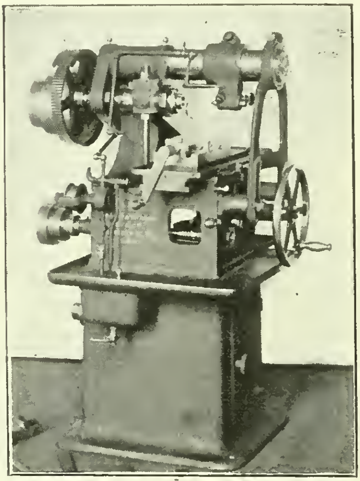

Fig. 54 Obsolete Type of Milling Machine with Exposed Gears

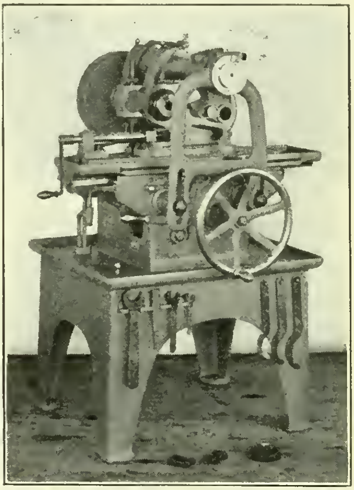

Fig. 55 Milling Machine with Gears Completely Encased

Fast and Loose Pulleys. Mr. Calder emphasizes the danger, where fast and loose pulleys are used, of the belts becoming wound on the shaft. A chief source of danger from this cause lies in having too little space between the pulley and the hanger, so that when belts slip off they are apt to wedge, as shown in Fig. 59. This will endanger the workmen, as the countershaft may be pulled down on him. Fig. 60 shows the proper arrangement with sufficient space allowed so that if belts slip off they cannot wedge and wind on the shaft.

Guarding Wood-Working Machinery. The problem of guarding circular saws, planers, jointers and other wood-working machines has proved one of the most difficult in our experience. We have found nothing on the market to meet our needs in this direction and our own efforts have been only partially successful. It is our practice to provide rubber mats in front of wood-working tools where there might otherwise be danger of the workman slipping and injuring himself on revolving saws or cutters. Fig. 61 shows our method of guarding a band saw, the guard being hinged for convenience in replacing the saws. It will be noticed that there is also a head guard covering the saw and preventing the workman's head from coming into contact with it. An exhaust is provided to carry away the sawdust.

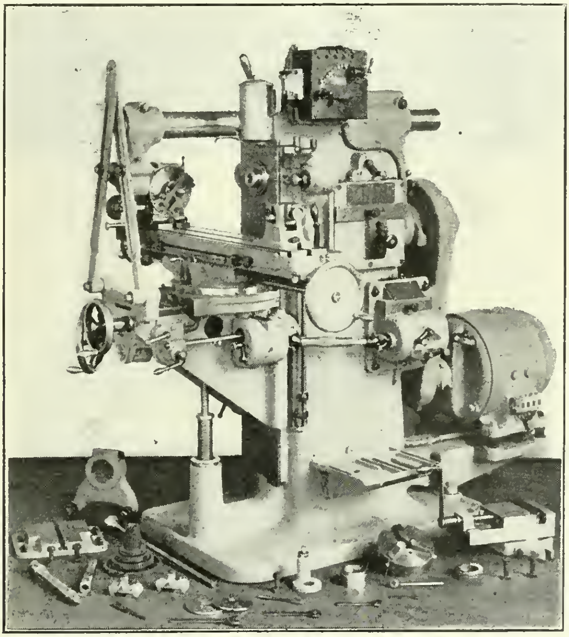

Fig. 56 Milling Machine with Gears Inside the Frame

Foundry Safeguards. Fig. 62 shows an interior view of the foundry with overhead tracks for moving ladles and castings about. These tracks are provided with switches and are so safeguarded that when the switches are open the truck is prevented from running off and falling on the workmen. Fig. 63 gives the view of the foundry cupola showing an elevator opening under the pouring spout so that large ladles can be filled. When small ones are being filled the

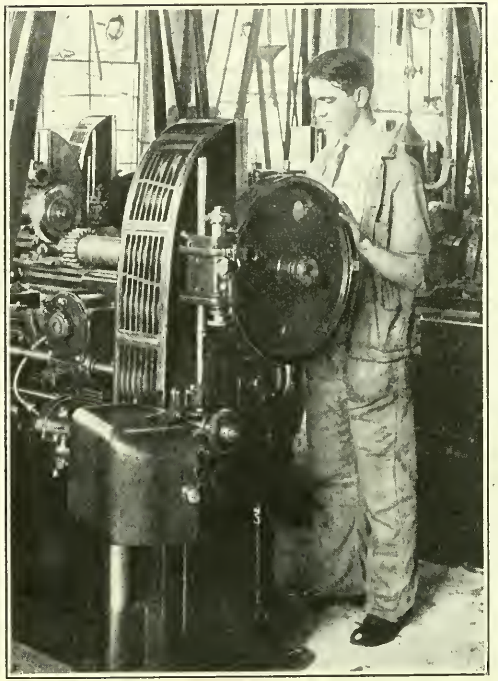

Fig. 57 All Apprentices are Required to Wear Short Sleeves

Note the swinging cover for the gears, which is closed when the machine is in operation.

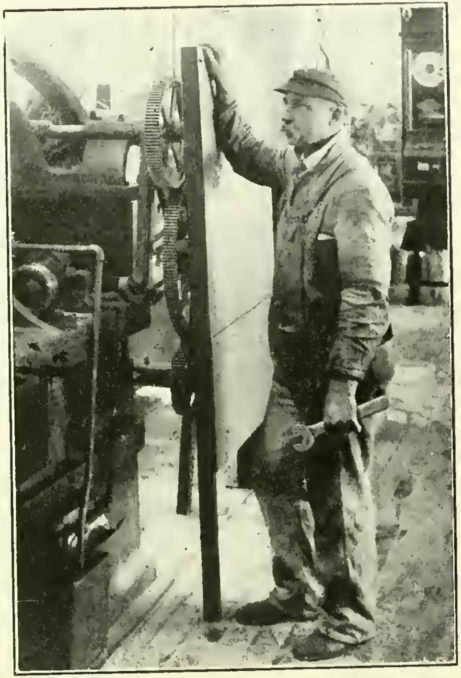

Fig. 58 Temporary Shield for Old Machine with Exposed Gears

platform of the elevator can be raised even with the level of the floor so that there will be no opening into which a workman might fall. This can remain closed when the cupola is not in use.

Engine Stop. Provision is made throughout the works, except where independent motors are used, to stop the engine by pushing an electric button conveniently located on each floor. The pushing of any one of these buttons sets in motion the counter weighted mechanism which shuts off the steam and stops the engine without the delay of notifying the engineer.

Sanitary Provisions. Fig. 58 shows one of the wash rooms. Individual streams of hot and cold water are provided for each workman. It may be seen that the coat racks are provided with steam piping underneath to assist in drying the clothing when damp. In the nickel plating room provision is made for removing noxious fumes from the washing tanks by means of a hood and exhaust. Guards and exhausts are also provided for the buffing wheels.

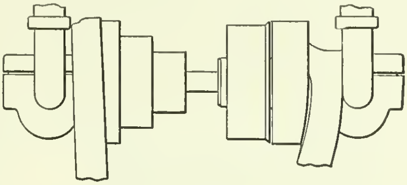

Fig. 59 Improper Design of Countershaft

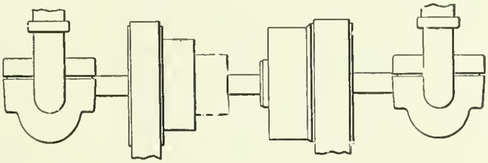

Fig. 60 Correct Design of Countershaft

Kinks for Preventing Accidents. The matter of safeguarding has its "kinks" and one of these which is effective in preventing accidents is that of hanging a piece of paper on the work projecting over the passageway, so that workmen will be warned in time and avoid running into it. Another "kink" is that of providing guards on the handles of a wheelbarrow so as to protect the hands and wrists of the workman when pushing it through swinging doors.

General Features of Safeguarding. It is the intention of the Brown and Sharpe works to give full consideration to all matters of health and safety and this policy has resulted in the adoption of many provisions working toward these ends. As an illustration, all stairways throughout the works are equipped with treads containing strips of soft metal to prevent slipping. Aside from providing especially favorable conditions as to light and air, special precautions are taken against the spreading of such diseases as tuberculosis by enforcing rules against spitting on the floors or stairways and by maintaining cleanliness in all parts of the shop. Provision is also made in each department for giving first aid to the injured. The main effort, however, is to reduce the number of injuries to the minimum and the last fatal accident in the machine shop of our works, now employing over 4000 men, occurred about 25 years ago.

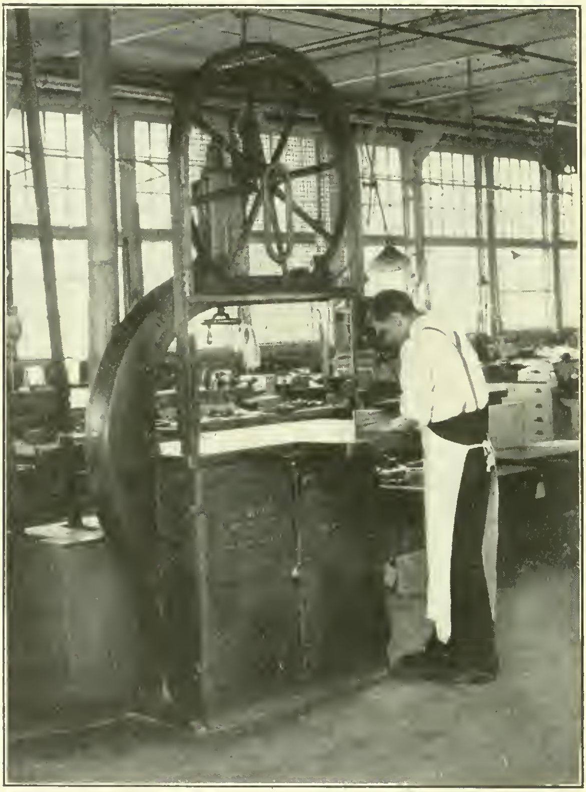

Fig. 61 Band Saw Completely Guarded

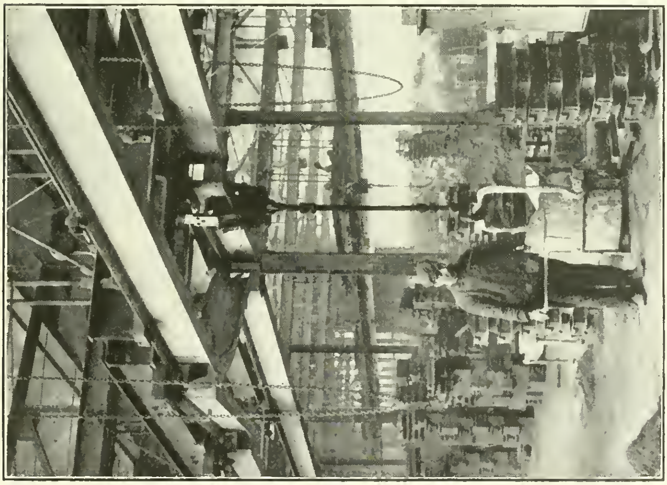

Fig. 62 Safety Stop at Open Switch to Prevent Truck from Leaving Overhead Rail

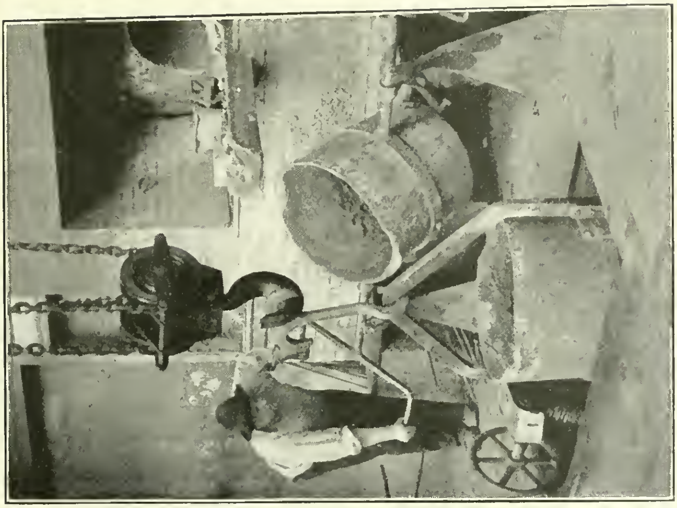

Fig. 63 Elevator Pit at Foundry Cupola
The elevator platform covers the pit when not in use.

M. W. Alexander. As a member of the Massachusetts State Commission on Compensation for Industrial Accidents, I have come in close touch with the public opinion of the State of Massachusetts, and through meetings with commissioners of other states have been able to test more or less the public opinion of the United States in regard to the problem of compensating the victims of industrial accidents. In my investigations I have found a surprising lack of appreciation both on the part of the general public and experts, of the importance of preventing accidents. The discussions have centered solely around amounts of compensation, maximum length of period of disability to be compensated for, and methods of administration; and while these discussions were going on month after month, no one seemed to take a keen interest in the preventive side of the question, so that the army of industrial victims might not meanwhile continue to increase. Sight seems to have been completely lost of the equally important, if in the long run not far more important, duty of preventing accidents, as far as they can be prevented by care and proper consideration. Accident prevention and acci-

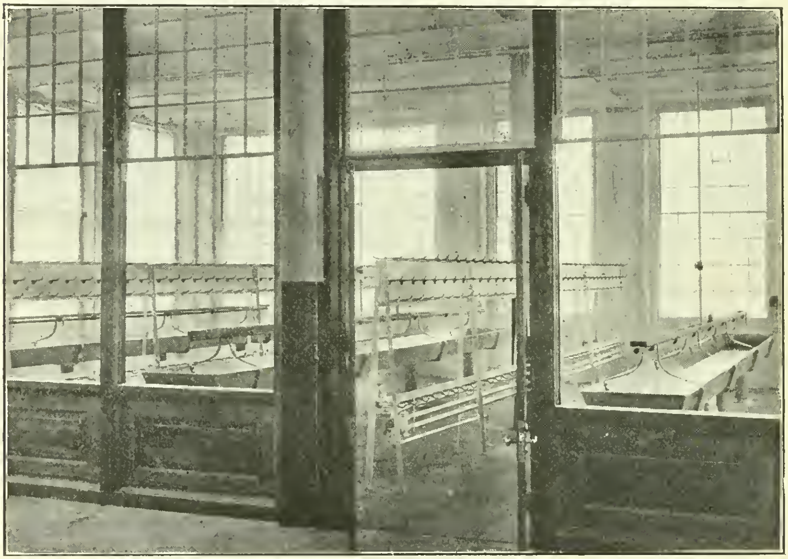

Fig. 64 Wash Room with Coat Racks and Individual Streams of Running Water

dent compensation are, after all, only two different phases of the same problem.

It is, therefore. very fortunate that Mr. Calder has so comprehensively called the attention of The American Society of Mechanical Engineers, and through it of the whole engineering profession, to a matter of such great importance, and Mr. Calder truly deserves the thanks of the Society for his excellent paper. While I might discuss some specific parts of this paper by adding my own opinion and experience, I believe it would prove of more value to point to some general considerations that deserve close study.

In dealing with the problem of accident prevention, we must go about it scientifically and imaginatively. We must not overlook the fact that this question is not only one of safety appliances and devices, but also one of proper safety rules and regulations; and the latter feature is often the more important one for its educative effect. Many times a machine quite properly safeguarded has, nevertheless, contributed to an accident because of a ragged coat sleeve, a loose necktie, or a finger ring on the operator, which have been the cause of the accident and often invited the same. I have seen one suggestion for safeguarding large gears which were partly above and partly below the floor line. Very properly, a railing and a toe guard were placed around the pit, yet there still seems to be an easy chance for a workman with a long coat or jumper passing near by or leaning over the rail, which was placed very close to the gears, to have his coat caught in the arms of the large gear. A further step might therefore have been taken in safeguarding this particular device by covering the arms of the gear with a sheet iron disc fastened to the gear without objectionable projections.

In this case, as in many others, half-way measures of safeguarding are often worse than none at all. On the other hand, there is also the danger of going too far in the direction of protecting the limbs and lives of operatives. In their desire to do the right thing, some men have endeavored to cover up every little crack or open space about a machine into which a man might be able to put his finger while the machine is in motion. Such procedure is not only wrong from an economic standpoint, but indefensible psychologically. I cannot quite believe that we will train up a body of the right kind of workingmen and with the right kind of fibre, if we make the machines on which they have to work, and the runways and everything else that surrounds them, absolutely fool-proof, for we are then in danger of making these same workingmen fools as far as looking out for their own safety is concerned. If a man is trained to consider every machine on which he works so safe that he can sleep all over it, so to speak, without getting hurt, he is surely bound to be caught and injured sooner or later when he is called upon to work on some other machine that is not so fully safeguarded; and there are thousands of machines in daily operation now which can only be safeguarded in time, and even then perhaps not as completely as new ones built with a view to proper safeguards. I am pleading, therefore, for safe machines rather than for fool-proof machines, because a fool-proof machine, as already stated, is apt to fool its operator. The best safety device, after all, we must admit, is good common sense and due care. It should, therefore, be the duty of all employers to pay careful attention to this phase of accident prevention, and to an intelligent effort for safeguarding the working places and the machines under their own control as well; at the same time they should exert all pressure possible to the end that machine tool builders will design their new machines with full consideration to the protection of the lives and limbs of the operatives.

Many corporations and individual employers are already doing excellent work in this respect, and the general public is beginning to be aroused to the importance of the problem of accident prevention. Much more, however, needs to be done to stimulate further effort and to give it proper direction and unification. It would seem to me to be of particular value to have all machine tools of a type, already installed in the various factories, safeguarded in a more or less uniform manner, so that the workingmen emigrating from one to another might be better protected because of their greater familiarity with the nature of the safeguards. A committee of experts could to advantage design and issue for wide publication standard safeguards for lathes, planers, drill presses, punch presses and other standard tools which are already in daily use. The same committee could secure from employers all over the country photographs of safety devices and copies of safety rules and regulations covering all kinds of conditions, and after proper and careful scrutiny issue to interested persons those which deserve wide publication and imitation. If there is already in existence such a body of experts or an association created for this purpose, I should respectfully ask them for a consideration of these and similar ideas. If, on the other hand, there is not already a hopeful effort under way, I should suggest to the Society the appointment of a strong working Committee on Safety Conditions, which might take initiatory action, coöperate with other similar bodies, or do both. The fact that practically all machine tool builders and the prominent mechanical engineers in the various industries are members of the Society would give such a committee a decided advantage in securing active coöperation of manufacturers and employers. What I desire to call to the attention of the Society in particular may be summed up in these three statements:

a The problem of preventing accidents involves safety rules and regulations as well as safety appliances; in other words, it is a question of safety conditions.

b Machines should be made safe in their operation rather than fool-proof.

c The problem of prevention of accidents will find its complete solution only if it is based on a campaign of education, both with the operatives who are to be protected and the engineers and employers, among whom a better knowledge of the subject and a strong public opinion in favor of safety conditions must be created. This, in turn, will have a helpful effect upon the legislators of various States before whom bills for accident prevention and accident compensation are pending at the present time. These bills, when enacted, should be comprehensive and constructive in character, and as far as it can be done, more or less uniform between the various States.

L. P. Alford. I am disposed to emphasize the importance of the position of the mechanical engineer in connection with this subject to a greater degree than did Mr. Calder. Legislation, official requirements and recommendations can do little more than point out that something must be done. The designing and applying of safeguards, and the determining of the details of manufacturing processes are distinctly within the province of the mechanical engineer. Upon his initiative and ingenuity rest the final solution of this economic problem.

Using the word prevention in the sense indicated in the old adage, "An ounce of prevention is worth a pound of cure," the time to establish industrial safeguards is when the work of designing is being done. The place to safeguard machinery, mechanism and structures, is on the drawing board. The time to safeguard a manufacturing process is when that process is being planned.

Turning to the field of the machine shop, my experience has shown two prolific sources of accidents that are worthy of consideration. Some time ago I had occasion to analyze the accidents that had taken place during two years in a large machine shop manufacturing light and medium weight, automatic and semi-automatic machinery. The records from which the analysis was made were of the best. The plant has a well equipped emergency hospital, in charge of a registered male nurse, and keeps an accurate record of every case that is treated, no matter how trivial it may seem to be.

The average number of employees for the two years under consideration was 2590. The number of cases treated during the two years, practically all injuries, but most of them of minor importance, was 5208, or about one per employee per year. The number of serious injuries or accidents was 174, divided as follows:

Lacerations and contusions of fingers, hands, wrists and forearms...	99
Lacerations and contusions of feet and legs	28
Lacerations and contusions of face and head	16
Miscellaneous	11
Received in drop forging shop	13
Received in iron foundry	7
Total	174

Disregarding the accidents received in the drop forge shop and foundry, and computing the machine shop accidents in percentage, we find that 64 per cent were in the nature of accidents to the fingers, hands, wrists and forearms, 18 per cent to the feet and legs, 10 per cent to the face and head and 8 per cent to other parts of the body.

Without taking time to present the analysis for the agent of the accident in detail, the two most prolific sources should be pointed out. One is the milling machine. Thirteen per cent of the accidents under consideration were from milling machines. In two cases amputations resulted. One of the most distressing machine shop accidents that I know of is the severing of the tendons of the wrist on a slitting saw or thin mill. I have seen several such accidents and in no case did the wound heal in a manner to leave the hand of much use thereafter. Yet the safeguarding of a milling cutter is an easy matter.

The greatest single source of accidents was from falling objects, in amount 24 per cent. Most of these were from castings and forgings that slipped from trucks while being transported, or fell from piles of material, or were dropped by the man injured or a fellow workman. This emphasizes the need of suitable transporting devices in shops and care in piling the material to prevent its falling.

Mr. Calder has not treated of the hazards around elevators and vessels under pressure, saying that of all industrial dangers they have received the most attention from engineers. While this is so, more needs to be done in certain directions.

The usual safety elevator gate constructed with a few horizontal bars, the lower one being from 8 to 12 in. from the floor, is to be condemned. Such a gate offers no safeguard to prevent objects from rolling into the elevator well. A single accident from my own experience will emphasize this point. A barrow of pig iron had been unloaded from a foundry elevator into the cupola charging floor. The elevator immediately descended. A helper in moving the barrow tipped it to one side, a half pig of iron fell off, rolled across the floor, passed underneath the bar of the so-called safety gate and fell. One man was instantly killed, a second seriously injured. Yet the gate was of a commonly approved type, hundreds of which are in use every day.

New processes often bring new hazards. The use of the oxy-hydric and oxy-acetylene fusing and cutting apparatus is our latest illustration in the machine-building field. Several fatal accidents have already occurred. On February 22 of last year an accident took place with an oxy-acetylene apparatus in this city, in which one man was instantly killed, a second seriously injured and a resulting fire caused considerable property loss. I investigated that accident and the facts as I was able to learn them are these:

The apparatus as furnished by the manufacturer consisted of two retorts for generating oxygen, gas scrubbers, an acetylene generator and the connecting piping and torches. The oxygen retorts were each a seamless cup, closed by a flanged head screwed into place. The acetylene generator was a seamless tank. To increase the capacity of this apparatus a large riveted tank was connected by the user into the oxygen system to serve as storage space. This riveted tank was apparently the one that exploded. It was ruptured nearly its entire length and was almost turned inside out. The flanged head was blown off from one of the oxygen retorts—perhaps by a flying piece from the storage tank.

This shows the ignorance that exists on the part of some users of apparatus of such serious hazard. Gases are confined under considerable pressure; one is inflammable in the air. If both are mixed together in proper proportions the mixture is violently explosive, and when in use they give some of the hottest flames used in industrial processes.

Here is a field in which some authoritative action should be taken. What is needed is a series of recommendations in regard to the design, installation, care and use of oxy-acetylene and oxy-hydric apparatus, with particular reference to safety; including tests that may be applied to new apparatus or apparatus in use to make sure that it is safe. This will be to the advantage of maker, owner and user of the appliances, alike.

Something has been done by the National Board of Fire Underwriters in recommendations seeking to reduce the fire hazard, but I believe that more is needed. Ultimately, we may look for legislative action, but we need something to bridge the interim and to form an intelligent basis for laws when they are drafted and passed.

A. Taylor. Little literature is even now available on the subject of accidents and their prevention, so that the average employer has been compelled to learn almost solely from his own experience and to endeavor to safeguard the future by his knowledge of the past instead of having the experience of others to assist him as is the case in so many other lines of work. It is fair to presume that when circumstances permit not only of a freer interchange of ideas but of the formation of some central bureau where such ideas may be properly compiled and then universally disseminated, there will be relegated to the preventable class a certain percentage of the accidents now designated as natural hazards incident to the various occupations, and any move with this desirable end in view should accordingly be facilitated in every possible way.

Every works should have its supervisor of safety appliances who should be an experienced mechanical engineeer and whose duties in whole or in part should be to see that the danger of accident from whatever cause, whether from machine tools, fire, steam, electricity, pits, translating devices, etc., is either eliminated entirely, or failing this, is minimized to the smallest degree. In any plant where work of this kind is being systematically introduced it will be advisable to consider the tools and other appliances as capable of division into three classes: first, those which should receive immediate attention as being dangerous in the extreme, and which should, therefore, be guarded without delay; second, those which are capable of producing injury but are of a minor character and the guarding of which may consequently be taken up after the more dangerous machines have been guarded; third, those in which the chance of injury is so remote as to be a negligible quantity and which accordingly need not be guarded at all.

It will also be found that the work involved is not alone one of installation but of up-keep as well, for it must be admitted that in many instances the guards employed, while performing their function, do so at the expense of production and under such circumstances are liable to be removed by the unthinking among the workmen; and for this same reason perhaps continue to be left off by the foreman under the mistaken idea that they are thus serving the best interests of all concerned. On the other hand, it will occasionally be noted that the use of properly designed safety appliances has actually increased production, as for instance, roll and inclined feed or suction and blower devices when applied to punch presses, etc., instead of the usual hand feed.

Doubtless the limits of the paper prevented the author from touching upon the guarding of traveling cranes by providing them with limit switches, thus preventing operators from over running and perhaps dropping the loads, with damage to property and risk to life. When cranes are unprovided with proper mounting platforms and are not too high up, it is sometimes advisable also to equip them with rope ladders whereby the operators are enabled to reach and leave their cages without the necessity of clambering over the cranes, thereby avoiding any possibility of falling or of shock from contact with the trolley wires. The sides of elevators should be guarded by low foot boards to prevent articles from going through to the floors below, and where this cannot be done, as on the open or approach side, the floor should, if possible, be given a slight rise. The same reason calls for similarly guarding stairs, and wide stairs should be provided with central railings. Hatchways and shafts should be lined with netting to safeguard heads, arms and feet, and elevator gates should likewise be so arranged, and moreover be sufficiently high to prevent leaning the arms on them or looking over them.

In the line of indirect safety appliances, if the term may be used, due importance, as the author of the paper points out, is not usually given to adequate lighting. A very great majority of factories, it is safe to say, are still illuminated by spot or individual lighting, a method considered obsolete, except in special cases, since the advent of incandescent and vapor lamps of medium candle power which now enable diffused lighting to be used. Unfortunately it is impossible to prove by the commonly accepted method of dollars and cents, to what extent betterment in lighting reduces the liability of accident, though it will be patent to everyone that the elimination of shadows by the use of diffused lighting in place of individual or spot lights with their sharp light and shadow effect must exert a very considerable influence, since eye-strain is wholly done away with; moreover, production is most certainly increased and the quality of the work improved.

Going perhaps a little further away from the subject, but nevertheless always a source of anxiety to the management, is the risk to life and limb when employees are boarding street cars and trains upon leaving work, the only solution to which problem is to coöperate with the railroads in the erection of suitable fences, gates or enclosures.

H. Gardner. Mr. Alexander referred to the advisability of properly instructing shop men and particularly apprentices in regard to the dangers of handling the machines they are operating. If we can bring to the men and the apprentices a proper realization of the dangers to which they are subjected and explain the exact location and nature of this danger in such a manner as to make them able to take proper precaution there will be less need for the more extravagant and elaborate types of safety devices.

The New York Central Lines with which I am employed have some 650 apprentice boys working in the several shops and we have found it profitable to inject into our educational courses carefully written suggestions relating to the care of self as well as the care of the machines. I would think that a dull boy going to the shop with a proper realization of the dangers to which he is exposed would be less liable to injury and less in need of guards around the machines than perhaps a brighter boy or even a mechanic who had not the advantage of being thus forewarned. The Brown and Sharpe Manufacturing Company have issued a hand-book for apprentice machinists containing paragraphs which ably present to the boy the need for proper care in handling machinery and undoubtedly the apprentices which Mr. Alexander has in his school at West Lynn are provided for in a similar manner.

We find that the instructor employed to train apprentices may be held largely responsible for accidents in the shop and it may be considered distinctly a part of his duty to point out the danger and stimulate individual responsibility in properly caring for machines and tools. There is no question but that proper education and instruction can help greatly in this direction.

Oberlin Smith. The paper just read is a very interesting and comprehensive one and should be followed in this and sister societies by many other papers upon this very important subject. It was of course impossible in treating such a great variety of machines to deal with each kind in detail. It is very desirable that the paper should be amplified by a treatise upon each particular kind of machine. It may be that experts in the different branches of manufacturing can be induced to write a series of papers, each one in regard to his own specialty. In this discussion, I will limit myself to that most dangerous class of implements known as presses and dies, it so happening that I am especially familiar with their doings and misdoings.

The first kind of danger incident to these machines, and one which threatens people in general moving about a shop, rather than the operator, is obviously the chance of being drawn in by belts and gearings. This can be obviated by guards arranged in any of the ordinary ways, some of which are shown by Mr. Calder.

In an experience, however, of some 40 years with these machines, I have known but few accidents of this kind. In my own practice I have not equipped presses with complete guards unless especially ordered and paid for by the customer, but a partial guard has always been placed between each pair of gears on the in-running side. This guard consists of a casting somewhat wider than the face of the gears, extending from the point of tooth contact through a considerable arc in the form of curved plates nearly touching the teeth. This has seemed to serve almost as good a purpose as guards running entirely around the gears and is not prohibitive in cost when included in the price which buyers will pay.

The next and most frequent kind of accident pertaining to a power press is the contusion or shearing off of fingers and hands by being between the dies when they come together. This often occurs through pure carelessness on the part of the operator. In cases where he lets the ram of the press run continuously, trusting to luck and to a certain acquired automatic rhythmic movement of his hands, any mental disturbance of the rhythm, as a sudden movement or noise in his vicinity, or a desire to look round for something happening in the street, may prove disastrous. Of course this cannot occur if the machine is arranged as it should be, so that his fingers cannot possibly go between the dies.

A more frequent accident occurs when the ram of the press is allowed to stop between each stroke by the action of the automatic stop-clutch generally embodied in these machines. Each operation consists in placing the work between the dies and then depressing the treadle, or in some rare cases a handle, which throws the clutch into mesh so that the continuously revolving flywheel operates the shaft through one revolution and then stops it. This performance is safe even if the fingers have been between the dies, providing they are taken out before the treadle is depressed and not put in again until the ram is surely stopped in up-position. It often happens, however, especially with piece work, that the treadle is depressed almost immediately after the ram is stopped so that again there is needed a certain rhythm common to the finger motions and the halting continuity of the ram motion. Under these conditions it is probable that most of the accidents happen because the treadle is not allowed to rise entirely to its upper position, that is, far enough to insure positively the stopping of the ram. In such a case it comes down a little sooner than is expected, and an injury to the hand is the result. A remedy for this evil has been devised by the writer and some other press makers in the shape of a device by which the clutch-lever detaches itself from the treadle action, each time the latter is depressed, by means of a cam upon the main shaft, which itself performs the stopping action of the clutch. This, if kept in order, will provide safety and is a valuable device.

A similar trouble may happen by the clutch being out of order so that the treadle and tripping device, often known as a clutch-lever, do not rise as promptly as they should, owing to the binding of some parts, or the weakening of springs which, perhaps, have not been kept in proper adjustment. An occasional trouble causing the ram to descend unexpectedly is the cutting or seizing of the flywheel, or gear upon the shaft. This, of course, is due to the lack of oil, or the presence of dirt, or both, between the wheel and the shaft. Nothing but correct automatic lubrication would seem to be a cure for it, and this is not usually applied to presses.

The cases are rare where fingers are deliberately placed between the dies and then the machine prematurely started, but even this happens sometimes. The only safe rule to follow, as a preventive of all the different kinds of accidents above referred to, is never to put fingers, hands, or arms between dies, while the flywheel or gearing of the press is in motion, even though the clutch may be fastened out of action by a clutch-lock, such as the writer has devised and always used, and further never so to place the fingers between the dies when nothing is in motion, without putting a block of some kind under the ram, or between the dies so that the ram cannot possibly descend by its own weight, or from other causes. Instead of such a block a safety-post might be made which could be swung up or forward underneath some part of the ram when not in action. In cases where hand feeding is practised, such a rule is difficult to enforce. The employers do not like it because it sometimes lessens the speed of feeding and the workmen dislike it for the same reason, when practising piece-work, or when expected to perform a given task. Even if ordered thus to protect themselves they often disobey simply from recklessness.

It would seem from the above facts that particular attention should be given to developing protective devices in and about the dies. This is done in many kinds of work, but it is difficult to make any general attachment to a press that will meet all the very numerous conditions attending the work done therein. Of course the dangers alluded to can be almost eliminated when strictly automatic feeds are used.

Considering first, primary operations, as the working of cutting, punching or shearing dies, all of which may easily be protected, the most usual feeds are:

a Single or double roller-feeds, where the flat sheets or bars of metal or other material are held by spring pressure between intermittently revolving rollers.

b Reel-feeds, where flexible metal or other material, in strips, is pulled through the dies from one reel with a brake upon it by another intermittently revolving reel upon which it is rewound.

c Grip-and-push or pull-feeds, generally made with a pair of stationary grippers and a pair of reciprocating sliding grippers, these latter alternately gripping the edge of the material and carrying it through the dies any desired distance at each stroke of the press.

d Gravity-feeds, where the press ram axis is inclined at an angle to the vertical, perhaps even to a horizontal position, and the material descends by gravity against a let-off gage, placed back of the dies, working automatically.

Concerning feeds for seconding operations the most usual kinds are:

e Dial feeds for redrawing, forming, curling or repunching work. A common well-known form consists of an intermittently rotating disc in the respective apertures of which the work is put by hand at the front of the press, far away from the dies, and is carried around until it reaches them, in some cases a group of dies performing successive operations upon it.

f Friction-disc feeds, where the articles are pushed from a table on to a flat revolving disc which carries them by friction between certain fences or guides and which delivers them under the dies. They are stopped by a let-off device to limit the motion of each one as it arrives in final position.

g Push-feeds, where a sliding carrier comes forward to receive the work and then carries it back between the dies again, coming forward for another piece.

h Tube-feeds, used especially for small articles like coins, medals, etc., which are piled upon each other in a tube and allowed to descend by gravity so as to be fed to the dies by any one of the methods, *e*, *f* and *g*, usually, however, with the last.

Feeds *f* and *h* are practically safe against hurting the fingers, while with *e* and *g* there is some little danger of getting the fingers in the feeding device itself, if they are not removed quickly enough before it starts; they cannot, however, be easily carried back to the dies. When devices of this sort are used, by stopping the press at each stroke while the work is being placed in the dial, or carrier, absolute safety is assured.

Returning to the consideration of hand-feeding: With thin metals, mere cutting operations can be made entirely safe by using a proper stripper surrounding the punch. This should fit very close to the punch and come down as close to the top of the die as possible to allow the metal to go between, and it should be quite thin so as not to obstruct the view of the work outside the limits of cutting. It should also be so high that the punch at the top of its stroke never comes entirely out of it, thus giving no chance for fingers to be put in above it. With thick metals, the stripper has obviously to be placed so high that fingers can be put in under it.

In the case of forming, repunching, etc., where small objects must be located between the dies and sometimes a considerable distance in from the front thereof, it is nothing but criminal to allow the operators' fingers ever to go between. The inserting and removing of the work should always be done with a stick of pine wood, or some other soft material, which will not damage the dies if they happen to come down at the wrong time.

In general, where hand feeding is resorted to, there is no universal panacea for the evils in question. Careful attention to all of the points above mentioned, however, will reduce the percentage of danger to a very small figure, especially if there is any such rigid discipline, backed both by altruistic and financial motives, as will absolutely prevent fingers being put between dies. It may be stated that in any ordinary press shop where thousands of different kinds of work are to be done, and perhaps only small batches of a few thousand, or a million or two, of pieces are to be made, it is very expensive to provide all of the different kinds of automatic feeds and guards that would be needed for the varying kinds of work. If, however, we should get our much desired uniform state laws providing reasonable penalties for the carelessness and parsimony that produce our present numerous accidents it is probable that the volume of them will greatly decrease.

The writer has frequently had inquiries for safety apparatus for a room full of presses but has always been obliged to reply that each press and each pair of dies must be considered separately, and that much expert designing would have to be done for special devices to suit each varying condition. Some of these would of course be simple, but others would have to be automatic in their character and, on the whole, quite expensive. Hence, not many press manufacturers have gone into this matter thoroughly, principally because they know that their competitors would not be obliged to do the same.

The Author. It is gratifying that so much practical sympathy with the movement for prevention of industrial accidents exists within the Society, as exemplified by the participators in this discussion. The subject is a large one which demands for its full consideration a treatise instead of a paper and the author, being necessarily limited in the length of the paper and the number of illustrations permissible, has chosen to dwell mostly upon causes and principles and to illustrate these from the machinery elements which are most generally created and maintained in industrial establishments by the mechanical engineer to whom the paper is specially addressed.

All dangerous apparatus not detailed in the paper is not thereby to be considered of less importance. Its protection follows as a matter of course if the general contentions of the author are admitted. It is not the writer's experience that accidents invariably or even most frequently arise out of unrestrained or unguarded applications of power, though a number of very serious ones do.

Engineers in responsible control of industrial establishments and in daily contact with their accident risks are well aware that a large number of accidents, especially of the minor kind, have nothing to do with power machinery and are not preventable by specific safety devices. Many of them may be prevented, however, by the mechanical engineer through suitable structural precautions, caution and instruction of workmen, and cultivation of a safe-working habit of mind in foremen and overseers as well.

The totally inadequate financial and technical provision made by the various States for administration of accident prevention laws is well known and no employer should be content to rely for safety upon the infrequent visits of State officials.

If the members of the Society and the staffs of professional accident investigators attached to the casualty insurance companies will pool their practical experiences in discussions such as this, the writer feels certain that much good will be accomplished.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(VII)

ARTICLES IN PERIODICALS[1]

Aero and Motor Boat Exhibition at Olympia, The. *London Engineering, March 31, April 7, 1911.* 5⅓ pp., 7 figs., 4 tables. *b.*

A description of several sizes and types of English aero and marine engines.

Dieselmotoren, Thermodynamische untersuchung schnellaufender, M. Seiliger. *Zeitschrift des Vereines deutscher Ingenieure, April 15, 1911.* 5 pp., 8 figs., 3 tables, 5 curves. *b.*

An article on the thermodynamic investigation of high-speed Diesel engines. Notes great improvement in recent years.

Dieselmotoren, Uber die Verwendung von Teer in, K. Kutzbach. *Journal für Gasbeleuchtung und Wasserversorgung, April 29, 1911.* 3 pp., 1 fig., 4 curves. *A.*

Report of test of a Diesel motor using tar for fuel.

Dieselmotoren, Verwendung von Vertikalofen-Teer für, *Zeitschrift des Vereines deutscher Ingenieure, April 22, 1911.* ⅔ p., 1 table, 1 curve. *acf.*

An article on the value of tar fuel for the operation of Diesel oil engines.

Dieselmaschine für Schiffsantrieb, Eine doppelwirkendte, umsteuerbare Zweitakt. *Zeitschrift des Vereines deutscher Ingenieure, May 20, 1911.* $\frac{1}{10}$ p.

A paragraph notice of an article in *Engineering, May 5, 1911,* on a double-acting reversible two-cycle Diesel engine for ship propulsion.

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[1] Opinions expressed are those of the reviewer not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

Dieselmotoren, Die Abwärmeausnutzung bei, M. Hottinger. *Zeitschrift des Vereines deutscher Ingenieure, April 29, 1911.* 6½ pp., 8 figs., 2 tables, 3 curves. *bf.*

Engines For Sea-Going Vessels, Diesel, J. T. Milton. *The Mechanical Engineer (Manchester, England), April 14, 1911. abf.*

A serial article noting certain advantages of such motive power. Cites conditions to be met.

Engines for Sea-Going Vessels, Diesel. *The Engineer (London), April 14, 1911.* ⅔ p. *Aaef.*

Criticism of J. T. Milton's paper read at a meeting of naval architects. Article sets forth the economical advantages of the internal-combustion engine over those of the steam engine, also developments that may be expected in the near future, and prophesies oil engines of 20,000 b.h.p.

Engine, Lamplough's Two-Cycle Internal-Combustion. *The Mechanical Engineer (Manchester, England), April 14, 1911.* ½ p., 3 figs. *b.*

Account of a new arrangement of such engine.

Engine, A 1000 Horsepower Marine Oil, J. Rendell Wilson. *International Marine Engineer, May 1911.* 1 fig., ½ p.

A description of large 4-cylinder engine for a Congo boat.

Engine, A 180 Horsepower Marine Oil. *The Engineer (London), May 26, 1911.* 1½ pp., 5 figs. *Abf.*

Description of the Parson's oil engine (6-cycle) with compressor plant and reversing gears.

Engines, Diesel Marine, Th. Saiuberlich. *The Engineer (London), April 7, 14, 1911.* 6 pp., 23 figs., 5 tables, 3 curves. *Abf.*

Detailed description of the 200 h.p. and 90 h.p. oil engines for the propulsion of the service boat Frerichs and lugger Ewersand. Also description of the boats, giving their dimensions, operating expenses, etc.

Gases, The Methods of the U. S. Steel Corporation for the Technical Sampling of, J. M. Camp. *Metallurgical and Chemical Engineering, June 1911.* 4⅓ pp., 3 figs. *be.*

Description of methods and apparatus used for sampling and analysis.

Gas Engines for Power, John H. Norris. *The Gas Engine, May 1911.* 2 pp., 1 table. *Aadf.*

Paper read before the National Commercial Gas Association, Boston, giving various purposes for which the modern gas engine is used; also the B.t.u. consumed per b.h.p., and the cost per h.p. month of 234 working hours.

GAS ENGINE AND PRODUCER PLANT ON THE YACHT PROGRESS, 100 I.H.P. *London Engineering, June 2, 1911.* 3 pp., 13 figs.

Description of plant and its operation. Details of engine construction. Engine is 2-cycle, double-acting, with three cylinders, 8¼ in. diameter by 9 in. stroke. It develops 100 i.h.p. at 200 r.p.m. and is supplied with gas from a suction producer, which has been worked with anthracite, with coke and with coalite.

GAS ENGINES IN ENGLISH STEEL MILL, TWO-CYCLE. *The Gas Engine, June 1911.* 2½ pp., 1 fig. *bf.*

Description of four single-cylinder double-acting gas-driven blowing engines, two-cycle type, 1050 b.h.p. each cylinder cycle 35½ in. by 55⅛ in. stroke, 70 r.p.m. These blower engines are installed in the English Frodinghar Iron & Steel Co.'s works.

GASERZEUGER BAUART HILGER, DER DREHROST, Robert Bertelt and Georg Kassel. *Stahl und Eisen, April 6, 1911.* 1½ pp.

Correspondence anent the Hilger revolving grate gas generator.

GASERZEUGER, DER DREHROST UND DREMANTEL, BAUART KÜPPERS, Dr. Mardus. *Stahl und Eisen, April 20, 1911.* 4 pp., 3 figs., 1 table. *b.*

An article on the Küppers gas generator with revolving grate and revolving jacket.

GASOLINE-ELECTRIC CAR OF THE BUFFALO, ROCHESTER & PITTSBURG RAILWAY. *Engineering News, May 11, 1911.* ¼ p., 2 figs.

Short description of car for branch line service built by the General Electric Co.

GAS PLANTS FOR BITUMINOUS COALS, HOLBECK. *The Iron Age, May 18, 1911.* 1 p., 1 fig. *bf.*

Gas producer apparatus designed to use bituminous coal and lignites and interesting in respect to a rotary washer for cleaning the gas.

GAS POWER IN GERMANY, PEAT, F. E. Junge. *Power, June 6, 1911.* 2 pp., 1 fig. *abf.*

Description of the Heinz peat gas producer.

GAS POWER PLANT, A MUNICIPAL, T. E. Butterfield. *Power, May 2, 1911.* 3½ pp., 7 figs., 1 table. *ab.*

Description of a gas-power fire pumping station at Haddonfield, N. J. Operating features of the plant with table showing comparative cost of pumping water by steam and producer gas power.

Gas Producer, The Effect of Varying Proportions of Air and Steam on a. *The Engineer (London), May 5, 1911.* 1½ pp., 9 figs., 7 curves. *Abcef.*

Abstract of a paper read by E. A. Allcut before The Institution of Mechanical Engineers, April 28, 1911.

Gas Producers, J. E. Dowson. *London Engineering, May 5, 1911.* 4 pp., 6 figs., 15 tables. *Abcdf.* Also *The Engineer (London), May 12, 1911.* 2 pp., 6 figs., 4 tables.

Paper read before The Institution of Mechanical Engineers, London, April 28, 1911. A discussion on the different types of producers and systems of gas production with analysis of gas obtained.

Gas Producer, The Effect of Varying Proportions of Air and Steam on a, E. A. Allcut. *London Engineering, May 5, 1911.* 4 pp., 2 figs., 2 tables, 10 curves. *abc.*

Paper read before The Institution of Mechanical Engineers, London, April 28, 1911. Objects of research, record of tests. Description of plant and arrangement for trials. Analysis of gases and efficiency of producer.

Gas Producers, W. A. Tookey. *The Gas Engine, June 1911.* 9 pp., 4 figs. *ABabdf.*

Extract from paper read before the British Association of Engineers-in-Charge. Descriptive of various producers in general, including charcoal and coal dust producers, scrubbers, tar extractors, etc.

Gaspumpen und Kompressoren Humphrey, R. Dierfeld. *Journal für Gas und Wasserversorgung, April 15, 22, 1911.* 11 pp., 14 figs., 3 tables, 6 curves.

Abcf. Description of details of Humphrey gas pumps.

Gasreinigung, Die Entwickelung der, H. Wolfram. *Journal für Gas und Wasserversorgung, April 1, 8, 1911.* 13½ pp., 3 figs. *Abf.*

Methods of cleaning and purifying illuminating gas.

Generator Gas Locomobile. *Praktischer Maschinen Konstructeur, March 16, 1911.* ½ p., 2 figs. *Cb.*

Description of a gas engine outfit made by Capel & Co., Dalston Lane, N. E., consisting of gas producer, condenser, scrubber and engine. Gas engine cylinder diameter, 9 in., stroke, 15 in., flywheel diameter 4 ft. 8 in. Claimed to weigh by ⅔ that of a steam locomotive. Ready for service in 15 minutes. Operating cost $\frac{1}{10}$ of steam locomobile.

Lighting Plant, A Gas-Engine. *The Gas Engine, May 1911.* 1 p., 1 fig. *Babf.*

Description of a 1000 h.p. gas engine, direct-connected to a 480-kw. generator, running on 24-hr. per day lighting service.

Liquid-Fuel Supply, Henry Hale. *Cassier's Magazine, May 1911.* 14 pp., 14 figs. *Abdf.*

Developments in the oil fields of the Western United States giving yearly output and calorific value compared with coal.

Luftgas, Ueber, Busch. *Journal für Gas und Wasserversorgung, April 8, 1911.* 5 pp., 4 figs., 5 tables. *A.*

Description and reports on pent air gas plants.

Motor-Côte

A new type of gasoline motor, simple in design; remarkable arrangement of pumps.

Moteurs à Gaz. *Revue de Mécanique, April 30, 1911.* 11 pp., 40 figs., 2 tables.

Description and cuts of the following types of gas engines and gas motors: Anderson Foundry, Glasgow; Gas Power Co., Elyria, O.; Hamilton, Sandiacre, two-cycle motor; Fullagar, Head New Castle, two-cycle motor; Hopkins, Manchester, two-cycle motor; Barclay, Birkenhead, two-cycle motor; Pengemet, Billancort, two-cycle motor; Kilburn, Bolton, two-cycle motor; Badger & Whitacker, Rotherham, two-cycle motor.

Moteurs à Petrole sans Soupapes, Quelques. *Le Mois Scientifique et Industriel, April 1911.* 4 pp., 12 figs.

Moteur Rotatif, Roots. *Fer et Acièr, March 1911.* 5 pp., 1 fig.
Description of a rotating gas motor, Root System.

Motor Ships, French Auxiliary, J. Peltier. *International Marine Engineer, May 1911.* 3 pp., 6 figs.

Description of adaptation of oil engines as auxiliaries to sailing vessels by French merchants.

Poussières Combustibles, Étude comparative au point de vue de l'inflammabilité, des, Taffanel and Durr. *Comité Central des Houilleries de France, April 1, 1911.* 6 pp., 10 figs., 1 table. *Acf.*

Comparative study of combustible gases (mines) in reference to their inflammability.

Producer Gas, Formation of, J. K. Clement, L. H. Adams and C. N. Haskins. *The Gas Engine, June 1911.* 2 pp. *Bcf.*

Extract from Bulletin No. 7, Bureau of Mines.

Producer-Gas Power Plant, A 1000 h.p. Oil Fuel. *Engineering News, May 18, 1911.* 1 p., 2 figs.

Descriptive of gas electric power station being built for the Holton Power Co. of El Centro, Cal., from information furnished by International-Amet Gas Power Co. and Allis-Chalmers Co.

Producer-Gas Plant, A Bituminous. *Power, April 25, 1911.* 2 pp., 3 figs.

Description of plant and details of operation.

Producer Gas from Crude Oil, E. C. Jones. *The Gas Engine, June 1911*· 1½ pp., 3 tables. *Abcdef.* Also *Power, May 23, 1911.* 1 p., 3 tables.

A paper presented at the San Francisco meeting of The American Society of Mechanical Engineers treating of the production of gas from crude petroleum.

Producer Gas Yacht, A. *The Gas Engine, May 1911.* ½ p. *Cbcf.*

Description of 54 ft. yacht being built by McLaren Bros., Scotland, equipped with 45 h.p. gas engine, producer, electric generator and motor for propulsion.

Pump, Internal Combustion, The Babcock Two-Cycle. *London Engineering, May 5, 1911.* 1⅔ pp., 5 figs. *bc.*

A self-contained water pumping unit.

Tractor, Oil Railway. *The Engineer (London), May 12, 1911.* 1 p., 3 figs., 1 table. *Cbf.*

Thirty h.p. tractor on a railway in India. Speed 25 miles on level, capacity 18-20 tons up incline of 1 in 150. Fuel, paraffin.

Trunk Pistons for Gas Engines, Fitting, O. Olafsen. *Power, April 18, 1911.* 2 pp., 2 figs., 3 tables. *f.*

GENERAL NOTES

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

The third semi-annual meeting of the American Institute of Chemical Engineers was held on June 21-24 at the Congress Hotel, Chicago, Ill. Papers were presented on the Four-Year Chemical Engineering Course, J. H. James; Industrial Chemical Calculations, J. W. Richards; A New System of Lead and Silver Lining for Chemical Apparatus, C. L. Campbell; The Practical Value of Calorific Tests on Anthracite Coal, S. F. Peckham; and other subjects. Excursions were made in conjunction with the meeting, to the plant of Swift and Company, and that of the Corn Products Refining Company at Argo, the laboratories of the Dearborn Drug & Chemical Works, and the works of the By-Products Coke Corporation at South Deering, the Carter White Lead Company, West Pullman, and the Indiana Steel Company at Gary. A dinner was held on June 22 at the Congress Hotel.

SOCIETY OF AUTOMOBILE ENGINEERS

The summer meeting of the Society of Automobile Engineers was held at the Algonquin Hotel, Dayton, Ohio, on June 15-17, 1911. The meeting was opened on Thursday at 8.30 a.m., by the president, Henry Souther, Mem. Am. Soc. M. E., who made an address. Reports were received from the Standards Committee, iron and steel division, given by Henry Souther, Mem. Am. Soc. M. E., aluminum and copper alloys division, by W. H. Barr, seamless tubes division, by H. W. Allen, Mem. Am. Soc. M. E., and nomenclature division, by P. M. Heidt. Papers were presented on the Question of Long vs. Short-Stroke Gasoline Motors, by J. B. Entz, and Long Addendum Gears, by E. W. Weaver. At the professional session on Thursday evening, Commercial Vehicles was the topic for discussion, with a paper on the Influence of the Engineer on the Sales Department, by W. P. Kennedy. The professional session of Friday morning included papers on the Elements of Ball and Roller Bearing Design, by A. C. Koenig, and Worm Gears and Wheels, by E. R. Whitney, with reports from the Standards Committee, among others, the ball-bearings division, by David Fergusson, and the breaches division, by Charles E. Davis, Mem. Am. Soc. M. E. The final professional session, held Saturday morning, included papers on Rotary Valve Gasoline Motors, by C. E. Mead, Some Points on the Design of Aluminum Castings, H. W. Gillett, Oversize Standards for Pistons and Rings, James N. Heald, and reports of Standards Committee, lock washer division, J. E. Wilson, Mem. Am. Soc. M. E., sheet metals division, J. H. Foster, and others. On the afternoons of Thursday and Friday, aeroplane flights on the Wright brothers' grounds were viewed, and excursions were made to factories, while on Saturday a banquet was held at the Automobile Country Club, with an address by Arthur Ludlow Clayden, editor of the Automobile Engineer (London).

NATIONAL GAS AND GASOLINE ENGINE TRADES ASSOCIATION

The meeting of the National Gas and Gasoline Engine Trades Association was held on June 20-23, 1911, at the Hotel Pontchartrain, Detroit, Mich. Papers were presented at the professional sessions on the Relation of Ignition to the Sales Department, R. H. Combs; on the Development of Farm Power, J. E. Waggoner; the Work of the Colleges in connection with Agricultural Power, J. B. Davidson, Mem. Am. Soc. M. E.; the Commercial Side of the Agricultural Power Question, P. E. Edwards; Aeronautic Motors, E. W. Roberts; and others. Trips were made to a number of the automobile and engine factories in Detroit and an excursion taken on the lake.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

The 28th annual convention of the American Institute of Electrical Engineers was held on June 26-30, 1911, at the Hotel Sherman, Chicago. Sessions were held on Power Stations, Electric Lighting, Railways, Industrial Power, Telegraphy and Telephony, Education, and High Tension, at which a large number of papers were presented and discussed, including the Development of the Modern Central Station, C. P. Steinmetz, Mem. Am. Soc. M. E.; Tests of Oil Circuit Breakers, E. B. Merriam; Important Features entering into Making of Appraisals, H. M. Byllesby, Mem. Am. Soc. M. E.; Some Data from the Operation of the Electrified Portion of the West Jersey and Seashore Railroad, B. F. Wood, Mem. Am. Soc. M. E.; Analysis of Electrification, W. S. Murray; Induction Machines for Heavy Single-Phase Motor Service, E. F. W. Alexanderson; Automatic Motor Control for Direct-Current Motors, A. C. Eastwood; Control of High Speed Electric Elevators, T. E. Barnum; Multiplex Telephony and Telegraphy by Means of Electric Waves guided by Wires, George O. Squier; Transmission System of Southern Power Company, W. S. Lee, Mem. Am. Soc. M. E.; and Tentative Scheme of Organization and Administration of a State University, R. D. Mershon, Mem. Am. Soc. M. E. A number of trips were made to plants in the vicinity and social features for both members and ladies provided.

AMERICAN WATER WORKS ASSOCIATION

The 31st annual convention of the American Water Works Association was formally opened at Rochester, N. Y., on June 6, by John W. Alvord, president. A number of committee reports were presented and the following officers elected: President, Alex. Milne; Vice-Presidents, D. R. Gwinn, R. J. Thomas, J. A. Affleck, G. C. Earl, Thos. Leisen; Secretary-Treasurer, J. M. Diven. It was decided to hold the next convention in Louisville, Ky. The following papers, among others, were presented at the professional sessions: Fire Line Meters, George Houston; Pumping Station Equipment and Management at Milwaukee, Thos. McMillan; Some Fundamental Considerations in the Determination of a Reasonable Return for Public Hydrant Service, Leonard Metcalf, Mem. Am. Soc. M. E., Emil Kuechling and W. C. Hawley; Wood-Stave Pipe, C. T. Hatton; Water Purification, J. L. Leal. A talk on the Panama Canal, illustrated by lantern slides, was given by D. H. Maury, Mem. Am. Soc. M. E.

NATIONAL ELECTRIC LIGHT ASSOCIATION

The National Electric Light Association held what is considered to be the largest technical convention ever held in this country in the Engineering Societies Building, New York, during the week of May 28, 1911, with a registration of 5149. The convention opened with a reception at the Hotel Astor on May 29, and many other social events added to the pleasure of the visitors, including trips up the Hudson River and to Coney Island, as well as excursions to places of technical interest. Owing to the large number of sessions, it was necessary to hold simultaneous meetings. Many valuable reports on subjects of interest to the association were presented, representing extended research and experimental work on the part of the committee. The meeting at which was given the report of the Public Policy Committee, consisting of C. L. Edgar, Mem. Am. Soc. M. E., N. F. Brady, E. W. Burdett, H. M. Byllesby, Mem. Am. Soc. M. E., H. L. Doherty, Mem. Am. Soc. M. E., W. W. Freeman, G. H. Harries, Saml. Insull, J. B. McCall, Saml. Scovill, C. A. Stone, Mem. Am. Soc. M. E., and Arthur Williams, was held at the New Theatre, where an address was made by the Hon. Charles Nagel, Secretary of Commerce and Labor. A session on rate-making was held during the convention, at which a number of papers were presented, including Breadth of Vision in Public Utility Appraisals, H. M. Byllesby, Mem. Am. Soc. M. E.; Elements Affecting the Fair Valuation of Plant and Property, W. F. Wells; Standardizing Electric Sales, Douglas Burnett; Possibilities of Economy in the Operation of Light and Power Companies offered by Scientific Time Study, L. B. Webster, Mem. Am. Soc. M. E. Among the papers presented at other technical sessions were those on Grounding Low-Tension Circuits as a Protective Measure, P. M. Spencer; Recent Improvements in the Single-Phase Motors, M. A. Layman; Ventilation of Turbo-Generators, R. B. Williamson; Increasing the Flexibility and Reducing the Cost of Operation of Steam Boiler Plants by the Use of Fuel Oil, H. A. Wagner; and a Topical Discussion on the Operation of Transmission Systems, opened by D. B. Rushmore, Mem. Am. Soc. M. E.

The following officers were elected: J. F. Gilchrist, President; F. M. Tait, A. S. Huey, Vice-Presidents; and T. C. Martin and G. H. Harries were recommended for appointment as Secretary and Treasurer, respectively.

AMERICAN INSTITUTE OF MINING ENGINEERS

At the meeting of the American Institute of Mining Engineers held at Wilkes-Barre on June 6–10, 1911, a number of technical excursions were made to points of interest to the membership, including the mineral spring breaker of the Lehigh Valley Coal Company, at Parsons, Pa., the Hazard Manufacturing Company, Wilkes-Barre, Pa., Hauto storage yard and the Lansford briquetting plant of the Lehigh Coal and Navigation Company, Lansford, the Summit Hill mine fire, the Mauch Chunk, Summit Hill and Switch-Back Railroad, both at Mauch Chunk and the Saucon and Lehigh plants of the Bethlehem Steel Company. Papers were presented on Geology of the Cobalt District, R. E. Hore; Lead-Smelting on the Ore-Hearth, J. J. Brown, Jr.; Use of Electricity in Anthracite Mining, D. B. Rushmore, Mem. Am. Soc. M. E.; Mine Rescue Work in Illinois, J. A. Holmes, Mem. Am. Soc. M. E.; Apparatus for Metallography, C. H. Hayward; and many others.

PERSONALS

William M. Armstrong, formerly vice-president of the F. A. Goodrich Co., St. Louis, Mo., has been appointed treasurer of the Corrugated Bar Co. of the same city.

Earle J. Banta has been appointed general sales manager of the Davenport Locomotive Works, Davenport, Ia. He was until recently associated with the Vulcan Steam Shovel Co., Toledo, O., in the capacity of chief engineer.

Edward P. Bates will attend the fiftieth congress of the Institution of Naval Architects, which will be held in London on July 4. He is a delegate from the sister society in the United States.

Paul P. Bird, until recently smoke inspector for the city of Chicago, has taken a position with the contract department of the Commonwealth Edison Co., Chicago, Ill.

Frank G. Bolles has become associated with the Advance Sales Corporation, New York. He was formerly connected with the Reliance Engineering and Equipment Co., Milwaukee, Wis.

The degree of Doctor of Science was conferred upon John A. Brashear by Princeton University at its annual commencement on June 13th.

Willard C. Brinton, formerly with the Westinghouse Electric and Manufacturing Co., East Pittsburg, Pa., is now assistant vice-president of the U. S. Motor Co., New York.

A. H. Case has accepted the position of assistant manager of the Tennessee Copper Co., Copperhill, Tenn. Mr. Case was until recently identified with the Santa Fé Gold and Copper Mining Co., San Pedro, New Mexico, in the capacity of superintendent.

J. J. Chisholm, formerly chief engineer of power house of the Westinghouse Electric and Manufacturing Co., East Pittsburg, Pa., has assumed the duties of superintendent of power for the Tennessee Coal, Iron and Railroad Co., Ensley, Ala.

Farley G. Clark has been appointed superintendent of the Westinghouse Electric and Manufacturing Co., East Pittsburg, Pa. He was formerly connected with the P. T. & T. R. R. Co., Pennsylvania Station, New York.

Charles J. Davidson has resigned as chief engineer of power plants of the Milwaukee Electric Railway and Light Co., and as general superintendent of the Milwaukee Central Heating Co., to engage in private practice of engineering as a member of the firm of Woodmansee, Davidson & Sessions.

G. H. Gleason has become vice-president of The Dexter Engineering Co., Inc., Providence, R. I. He was formerly engineering salesman of the Dodge Manufacturing Co., Boston, Mass.

Charles Guckel has accepted a position with the Swan Falls Power Co., Nampa, Idaho, in the capacity of general manager. He was formerly secretary, treasurer and general manager of the Dover Electric Light Co., Dover, N. J., and the Rockaway Electric Light and Improvement Co.

Walter S. Hanson, formerly president of the El Reno Alfalfa Milling Co., El Reno, Okla., has been appointed manager of the Hollis Cotton Oil, Ice and Light Co., Hollis, Okla.

Parker H. Kemble, district manager of the Edison Electric Illuminating Co. of Brooklyn, N. Y., has been appointed sales manager of the Toronto Electric Light Co., Toronto, Canada.

H. B. Lange, formerly located in New York, has become associated with the American Optical Co., Southbridge, Mass., along lines of scientific management.

D. J. Lewis, Jr., has retired as manager of the Bundy department of the American Radiator Co., New York, and is now sales manager of the Lytton Manufacturing Corporation, New York.

J. R. McColl, of the firm of Ammerman, McColl & Anderson, has been appointed Dean of the newly organized engineering department of the University of Detroit, hitherto known as Detroit College.

Walter M. McFarland will represent the Society of Naval Architects at the fiftieth congress of the Institution of Naval Architects, to be held in London on July 4.

Cornelius T. Myers, formerly associated with the Wisconsin Engine Co., Corliss, Wis., as assistant secretary and assistant treasurer, has become identified with the General Motors Co., Detroit, Mich.

Horace Field Parshall has been appointed chairman of the Central London Railway, London, England.

Louis E. Polhemus has accepted a position with the Cubo Mining & Milling Co., Guanajuato, Mexico. He was until recently connected with the Mexican Light and Power Co., Necaxa, Mexico, as assistant master mechanic.

W. L. Saunders, president of the Ingersoll-Rand Co., New York, has been elected a director of the International Harvester Co.

Rupert K. Stockwell has accepted a position with the Tennessee Copper Co., Copperhill, Tenn. He was until recently associated with the Alpha Portland Cement Co., Easton, Pa., in the capacity of assistant general superintendent.

Charles E. Sweet has been appointed general superintendent of the Northway Motor and Manufacturing Co., Detroit, Mich.

C. N. Thorn has resigned his position of purchasing agent of Hugh Kelly & Co., New York, to become affiliated with the Allied Machinery Co. of America, New York, in the capacity of assistant general manager.

Paul C. Van Zandt has become district manager of Stephens-Adamson Manufacturing Co., Chicago, Ill. He was formerly connected with the cement department of the Allis-Chalmers Co., Chicago, Ill.

W. M. White, formerly hydraulic engineer with the I. P. Morris Co., Philadelphia, Pa., has assumed the duties of manager and chief engineer of the hydraulic turbine department of Allis-Chalmers Co., Milwaukee, Wis.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

American Telephone and Telegraph Company. Annual Report of the Directors to the Stockholders. 1910. *New York, 1911.* Gift of the company.

Association of American Portland Cement Manufacturers. Bulletin Nos. 1, 12, 18, 19, 20. *Philadelphia.* Gift of the association.

Building for Profit. By R. P. Bolton. *New York, 1911.* Gift of author.

Chilton Aero Directory. Vol. 1, No. 1, 1911. *Philadelphia, 1911.* Gift of Chilton Company.

Coal Washing. By G. H. Williams. *Chicago.* Gift of Foust Concentrator Company.

Composition and Heat Treatment of Steel. By E. F. Lake. *New York, McGraw Hill Book Co., 1911.*

The author has condensed in this work much information as to the composition, properties and treatment of modern compound steels, which would otherwise be found in scattered articles in periodicals. There are special chapters on annealing, tempering and hardening, and a timely description of the electric furnace. This summary of modern methods of steel manufacture is a welcome addition to the literature of the subject. The work is profusely illustrated.

Congreso Cientifico (Pan Americano) Ciencias Juridicas. VI Seccion. Vol. 7. *Santiago de Chile, 1910.*

——Ciencias Economicas y Sociales. VII Seccion. Vol. 8. *Santiago de Chile, 1911.* Gift of Scientific Congress.

Construction and Working of Internal Combustion Engines. By R. E. Mathot. *New York, D. Van Nostrand Co., 1911.*

The author is a member of The American Society of Mechanical Engineers, a consulting engineer at Brussels, and this edition is a translation made by an English engineer. The work is of interest especially for its description of the construction of Continental and British engines of the larger powers; the details of construction of the various parts are fully treated, and a table of tests is given. There is also a short bibliography and a list of engine builders.

Dampfkessel-Feuerungen zur Erzielung einer möglichst rauchfreien Verbrennung. Ed. 2. By F. Haier. *Berlin, 1910.*

Evaporating Condensing and Cooling Apparatus. By E. Hausbrand. Translated from the second revised edition by A. C. Wright. *London, 1908.*

FORTSCHRITTE DER TECHNIK. Vols. 1–2, 1909. *Berlin, 1909.*

GREAT BRITAIN STATISTICAL DEPARTMENT. Statistical Abstract for the Principal and Other Foreign Countries and Each Year from 1898–1908, 1909. No. 36. *London, 1911.*

HANDBOOK OF MODERN STEAM FIRE-ENGINES. Ed. 2. By S. Roper. *Philadelphia, 1889.*

HISTORY OF MECHANICS. By D. H. Ray. *Lancaster, 1911.* Gift of author.

HOLLAND AND COLONIES PATENT LAW OF NOV. 7, 1910. Translated by A. E. Doyer. *1911.* Gift of A. E. Doyer.

HUDSON FULTON CELEBRATION. Vols. 1–2, 1909. *Albany, 1910.* Gift of Hudson Fulton Celebration Commission.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS. 26th Annual Report, 1911. *Chicago, 1911.* Gift of the society.

INTERNATIONAL NIAGARA COMMISSION. [1]Projects of Cuenod, Sautter and others; Levy and Vigreux, Vigreux and Féray; Popp and Riedler, Lupton and Sturgeon, Pelton and Norwalk. *1890.*

——Report on Utilization of the Falls of Niagara by Means of Electricity. *1890.*

——Proceedings, *1890.*

——Designs of Niagara Falls Power Plant. Gift of Dr. William C. Unwin.

IOWA ENGINEERING SOCIETY. Proceedings of the 23rd Annual Meeting. *Iowa City, 1911.* Gift of the society.

LOGARITHMIC TRIGONOMETRICAL TABLES. Vol. 2. By J. Bauschinger and J. Peters. *Leipzig—New York, 1911.*

MARINE ENGINE DESIGN. By E. M. Bragg. *New York, D. Van Nostrand Co., 1911.*

MUNICIPAL ELECTRIC LIGHT INVESTIGATING COMMITTEE OF MARBLEHEAD, MASS., REPORT TO. By C. W. Whiting. *Boston.* Gift of author.

MÜNCHEN-KÖNIGLICHE TECHNISCHE HOCHSCHULE. Bericht, 1909–1910. *München, 1911.* Gift of Königliche Technische Hochschule zu München.

NEED OF EDUCATED MEN IN INDUSTRIAL AFFAIRS. By F. H. Taylor. (Lecture at Cambridge University, May 15, 1911.)

NEWCYCLE MOTOR. An Improved Type of Gas, Gasoline and Oil Engine, Description of. Gift of Newcycle Motor Company.

NEW YORK STATE AGRICULTURE DEPARTMENT. Proceedings of the 71st Annual Meeting of the New York State Agricultural Society, 1911. (Bulletin No. 23.) *Albany, 1911.* Gift of the department.

PRINCIPLES OF SCIENTIFIC MANAGEMENT. By F. W. Taylor. *New York, Harper & Bros., 1911.*

The work of Mr. Taylor, Past-President of The American Society of Mechanical Engineers, has aroused more popular interest than any other engineering discussion. No engineer in active practice can afford not to read this book; indeed, it is worthy the careful consideration of the thinkinglayman.

PRODUCTION OF MALLEABLE CASTINGS. By Richard Moldenke. *Cleveland, 1910.*

RAILWAY STATION SERVICE. By B. C. Burt. *New York, J. Wiley & Sons, 1911.*

The substance of this work was first made public in a short course of lectures delivered by invitation before the class on railway administration at Michigan University in 1909. The author has derived his knowledge from experience of a dozen or more years on two leading lines of the West. The book, although not designed as a manual explaining in a matter-of-fact way, either in complete detail or in outline, what things must be done at a railway station or how to do them, does state with some fullness the leading features of railway station service as matters of prescribed routine, and especially gives an insight into the general condition, spirit and principles of such service.

No other work has been published covering so intelligently the work of the local railroad representative and this should therefore be of great value both as a text books for students of railway matters and as a manual for station agents.

SUGAR MACHINERY. Ed. 2. By A. J. Wallis-Tayler. *London-New York.*

THEORY OF IONIZATION OF GASES BY COLLISION. By J. S. Townsend. *New York, D. Van Nostrand Co., 1910.*

UNITED STATES ORDNANCE DEPARTMENT. Report of the Tests of Metals. Vols. 1-3, 1909. *Washington, 1910.*

UNIVERSITY OF PENNSYLVANIA ENGINEERING ALUMNI SOCIETY. Annual Report, By-Laws and List of Members, April 1911. *Philadelphia, 1911.* Gift of the University.

UNIVERSITY OF TENNESSEE. Register, 1910-1911. *Knoxville, 1911.* Gift of the University.

WOOD PRESERVERS' ASSOCIATION. Report of Proceedings of 2d, 3d, 5th-7th Annual Meetings. *1906-1907, 1909-1911.* Gift of the association.

EXCHANGES

AMERICAN SOCIETY OF AUTOMOBILE ENGINEERS. Transactions. Vol. 5, 1910. *New York, 1910.*

CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members, 1911. *Montreal, 1911.*

——Report of Annual Meeting. Vol. 25, 1911. *Montreal, 1911.*

ELECTRIFICATION OF RAILWAYS (except minutes of Proceedings of the Joint Meeting of The Institution of Mechanical Engineers and The American Society of Mechanical Engineers, July 29, 1910). *London, 1910.*

INSTITUTION OF CIVIL ENGINEERS. List of Members, 1910. *London, 1910.*

INSTITUTION OF MECHANICAL ENGINEERS. List of Members, 1911. *London, 1911.*

SOCIETY OF AUTOMOBILE ENGINEERS. Transactions. Vol. 4, 1909. *New York, 1909.*

TRADE CATALOGUES

ASSOCIATION OF LICENSED AUTOMOBILE ENGINEERS, *New York.* Handbook of gasoline automobiles, 1911. 274 pp.

BRISTOL CO., *Waterbury, Conn.* Bull. 146A, long-distance recording tachometer, 2 pp.; Bull. 147A, radii averaging instrument for circular chart records, 7 pp.

BRUCE-MACBETH ENGINE CO., *Cleveland, O.* Vertical multi-cylinder gas engines, 31 pp.

A. D. GRANGER CO., *Philadelphia, Pa.* Bull. 1, steel tanks, 15 pp.

Hess-Bright Mfg. Co., *Philadelphia, Pa.* Cranehook thrust ball bearing mounting, 2 pp.; Typical mounting for high-speed spingle with pulley, 1 p.; Mounting ball bearing for radial load, 4 pp.

Industrial Instrument Co., *Foxboro, Mass.* Foxboro Recorder, vol. 3, no. 1, containing papers on the manufacture of instruments, 15 pp.

Keuffel & Esser Co., *New York.* Slide rules, 14 pp.

Chas. T. Main, *Boston, Mass.* Industrial plants designed and built, 61 pp.

Mississippi Wire Glass Co., *New York.* Wire glass in modern construction, 8 pp.

H. Mueller Mfg. Co., *Decatur, Ill.* Water, gas and plumbing, brass goods and tools, catalogue D, 1911, 600 pp.

Niles-Bement-Pond Co., *New York.* Progress Reporter, April 1911, on reversing motor planers, 20 pp.

Wm. Powell Co., *Cincinnati, O.* Catalogue 10, plumbing and steam fitting supplies, 326 pp.

Standard Third Rail Co., *New York.* W-S standard under-running third rail, 24 pp.

Westinghouse Machine Co., *East Pittsburg, Pa.* Circular W. M. 504, new model Roney mechanical stoker, 44 pp.

UNITED ENGINEERING SOCIETY

Eagle Almanac, 1911. *Brooklyn, 1911.*

International Waterways Commission. Report on Regulation of Lake Erie, 1910. *Buffalo, 1910.* Gift of the commission, American section.

Morton Memorial. A History of the Stevens Institute of Technology. *Hoboken, 1905.* Gift of A. C. Humphreys.

Preliminary Report on the Rock Asphalt, Asphaltite, Petroleum, and Natural Gas in Oklahoma. Bulletin No. 2, Oklahoma Geological Survey. *Norman, 1911.* Gift of Oklahoma Geological Survey.

Sanitary Code of the Board of Health, City of New York, 1910. *New York, 1910.* Gift of New York Department of Health.

Tribune Almanac, 1911. *New York, 1911.*

World Almanac, 1911. *New York, 1911.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0102 Wanted, man to take charge of cost work of a manufacturing concern of high grade machinery. Must be capable of doing estimating work, making proper comparative records and able to make recommendations to manufacturing department for cost reductions. Location New England. Applicant should state age, experience, and salary expected.

0103 Chief Draftsman. American with technical training preferred; should have had considerable experience in designing hoisting equipment. Location Iowa.

0104 Assistant professor of mechanical engineering to teach mechanics and assist in mechanical laboratory and general design work. Prefer a man with two or three years of practical experience. Location New England.

0105 High grade machine tool salesman or selling engineer, preferably a man about 35 having had shop and some commercial experience, and technical education capable of recommending equipment. Location Middle West.

0106 Engineering superintendent in small marine engineering plant. Must be capable of designing, handling and installing small marine engines, boilers, gasolene motors and their auxiliaries and of superintending the manufacture of same. Location Massachusetts.

0107 Young engineer, college graduate, some knowledge of electricity good mechanician, with aptitude for sketching and building models, etc. salary $100 a month to start. Location Connecticut.

0108 Member, prepared to go into partnership or associate with a manufacturing concern where in lieu of portion of salary will be given interest in the business. Equipped with all-round research and manufacturing experience in electrical and mechanical work.

MEN AVAILABLE

232 Technical graduate, four years experience in plant engineering in all phases, including cost reduction, accounting, tool systems, plant power operations, construction and maintenance, combined with extensive study of scientific management and accounting. Now employed. Thoroughly accustomed to handling men and working on own responsibility.

233 Graduate Mass. Inst. Tech., position with progressive manufacturing company or engineering firm. Experienced in power house design, supervision of construction. Last six years general manager of company employing 200 men. New England preferred.

234 Mechanical engineer extensive experience in the gasification of American fuels in gas producers, desires the association of capitalist or manufacturer in the building up of a line of gas producers from approved and well tried designs, for power, fuel and industrial applications.

235 Junior member, technical graduate, 6 years' experience in shop and drafting room. At present in charge of a small drafting room.

236 Junior member, M. E. Cornell. Five years practical experience in railroad shop and engineering work, special investigations in fuel and water economy. One year spent in Europe studying fuel economy and railroad engineering. Seeks connection with consulting engineers on power plant economy or industrial concern manufacturing railroad equipment. At present employed.

237 Member resident in Pittsburg, an experienced manufacturers' agent of standing and ability,wishes to secure the agency for steam or gas engine, steam or hydraulic specialties.

238 Mechanical engineer, technical graduate, junior member, age 29; experience covers designing and estimating costs with contracting engineer, manufacturing company in charge of work, executive with contracting company, at present employed; will consider position as branch or assistant manager, contract or sales engineer; prefers position in commercial work requiring technical training.

239 Junior member, 31, married, desires position as sales engineer, manager or similar position for power plant machinery of any kind; particularly familiar with pumping machinery, heaters and engines of all sizes and types. Designed several successful pumping plants. Good executive ability and successful salesman. At present employed but desires change. East preferred.

240 Sales engineer, college graduate, desires change; with present employer seven years, engaged in sale and installation of large power plants involving all types of prime movers. Will consider employment with banking interests,

in public utility corporations or executive position with operating company. Age 30 years.

241 Mechanical engineer, experienced in engineering and physical research, formerly in charge of design and construction of internal combustion engines, small and large, gas producers, and power stations, will undertake development or extension of product of manufacturing company.

242 Junior member, technical graduate, at present employed on the engineering staff of large corporation. Experienced in erection, testing and operation with a good knowledge of management. Desires a position where executive ability combined with mechanical knowledge is essential, in or near Philadelphia.

243 Member seeks a position as superintendent of machine shops, foundries, etc. Extensive experience in the building of heavy engines, air compressors, pumps, conveying and power transmission machinery.

244 Young engineer, 10 years practical shop and drafting experience, desires to connect with responsible engineering or contracting firm where there is opportunity for advancement.

245 Mechanical engineer, nine years experience, now in charge of six power plants, desires to connect with power or manufacturing concern, vicinity of New York, as assistant mechanical engineer or assistant superintendent.

246 Associate, mechanical engineer, technical graduate, ten years general engineering experience, at present in business as consulting engineer, wishes employment as mechanical engineer in manufacturing or engineering firm in or near New York City. Experienced in design and operation, power and manufacturing plants.

247 Member, experienced in erection and operation of turbines, both large and small units, also miscellaneous railway and power systems apparatus. Ability in organizing and training men.

248 Technical graduate, two years experience mechanical drafting and shop work, would like to connect with company manufacturing machinery, preferably gas engines, with view to working into sales or engineering department.

249 Junior member, age 27, technical education, eight years experience, at present employed by a public service holding corporation as mechanical engineer, operation, improvements, design and construction of power plants, handling of details of purchasing apparatus and closing of contracts and valuations of existing properties; desires change of position.

CHANGES IN MEMBERSHIP

CHANGES OF ADDRESS

ADAMS, Thomas D. (Junior, 1906), Werner & Pfleiderer, Saginaw, Mich., and *for mail,* Westport, Conn.

ALLEN, Albert Mark (1903; 1908), Cons. Engr., 1900 Euclid Ave., and 1503 E. 118th St., Cleveland, O.

ARMSTRONG, Wm. M. (Junior, 1894), Treas., Corrugated Bar Co., Bank of Commerce Bldg., and 5154 Westminster Pl., St. Louis, Mo.

ARNOLD, George, Jr. (1904), Cleveland Frog & Crossing Co., and *for mail,* 8217 Brookline Ave., Cleveland, O.

BAILEY, T. S. (1896; 1905), New London Ship & Eng. Co., Groton, Conn.

BANTA, Earle Jackson (1907), Genl. Sales Mgr., Davenport Loco. Wks., Davenport, Iowa.

BEHREND, Bernard A. (1909), Elec. and Mech. Engr., 442 John Hancock Bldg., 200 Devonshire St., Boston, Mass.

BILLINGS, A. W. K. (1909), care of Dr. F. S. Pearson, 25 Broad St., New York, N. Y.

BIRD, Paul P. (1907), Commonwealth Edison Co., 120 W. Adams St., and *for mail,* 1365 E. 48th St., Chicago, Ill.

BLAUVELT, Albert (1896), Asso. Mgr., West. Factory Ins. Asso., N. Y. Life Bldg., 39 S. La Salle St., Chicago, Ill.

BLUMGARDT, Isaac E. (Associate, 1908), 5 Woodcourt, Tarrytown, N. Y.

BOLLES, Frank G. (Associate, 1901), Advance Sales Corp., 50 Church St., New York, N. Y.

BOLTON, Reginald Pelham (1898), Cons. Expt., Pres., The R. P. Bolton Co., 55 Liberty St., and 638 W. 158th St., New York, N. Y.

BRINTON, Willard Cope (Junior, 1907), Asst. V. P., U. S. Motor Co., 61st St. and Broadway, and Harvard Club, 27 W. 44th St., New York, N. Y.

BROWN, Will H. (1909), Sales Agt., Toledo Elec. Welder Co., 706 Rose Bldg., Cleveland, and Willoughby, Lake Co., O.

BUCKLER, Albert H. (Junior, 1905), care of Inspr., Third Light House Dist., Tompkinsville, N. Y.

BURGOON, Charles Eli (1907), Burgoon-Matthews Elec. Co., 31 Luckie St., Atlanta, Ga.

BURTON, J. Harry (Junior, 1906), Lock Box 299, Portland, Ore.

CASE, Albert H. (Junior, 1903), Asst. Mgr., Tenn. Copper Co., Copperhill, Tenn.

CHISHOLM, John James (Associate, 1904), Supt. of Power, Tenn. Coal, Iron & R. R. Co., Ensley, Ala.

CLAPP, Geo. H. (1891), cor. 7th and Bedford Aves., Pittsburg, and Edgeworth, Pa.

CLARK, Farley Granger (1907), Supt., Westinghouse Elec. & Mfg. Co., East Pittsburg, and *for mail*, 6706 Penn Ave., Pittsburg, Pa.

CLARKE, Chas. L. (1882), Pat. Expt., Elec. and Mech. Engr., 30 Church St., New York, N. Y., and Plainfield, N. J.

DARBY, John Henry (1901), Howard Chambers, 155 Norfolk St., Sheffield, England.

DAVIDSON, Charles Jackson (1904), Member of Firm, Woodmansee, Davidson & Session, Inc., 1048 First Natl. Bank Bldg., Chicago, Ill.

DEARBORN, Wm. Langdon (Junior, 1892), Calle Enna No. 1, Apartado 1289, Havana, Cuba.

DILLARD, Capt. James B. (1907; Associate, 1909), Inspr. of Ordnance, U. S. A., care of Newport News Shipbuilding & Dry Dock Co., Newport News, Va.

DOUGLAS, Courtney Carlos (1904; Associate, 1908), Commer. Engr., Steam Turbine Dept., Genl. Elec. Co., Monadnock Bldg., Chicago, Ill.

EILERS, Karl Emrich (1890; 1904), Am. Smelting & Refining Co., 165 Broadway, New York, and *for mail*, Sea Cliff, L. I., N. Y.

FAILE, E. H. (Junior, 1907), Mech. Engr., 50 Church St., and *for mail*, 21 Claremont Ave., New York, N. Y.

FRANK, Edwin (Junior, 1909), Bergdrisch 21^1, Aachen, Germany.

GERNANDT, Waldo George (Junior, 1910), Ch. Draftsman, Carriage Chassis Dept., Packard Motor Car Co., and *for mail*, 940 Cass Ave., Detroit, Mich.

GLEASON, Gilbert Howe (Junior, 1906), V. P., The Dexter Engr. Co., Inc., Providence, R. I.

GUCKEL, Charles Henry (Junior, 1901), Nampa, Idaho.

GUMP, Walter B. (Junior, 1902), Mech. and Elec. Engr., 408 Union League Bldg., and 2510 Juliet St., Los Angeles, Cal.

GUCKEL, Charles Henry (Junior, 1901), Genl. Mgr., The Swan Falls Power Co., Nampa, Idaho.

HANSON, Walter S. (Associate, 1902), Mgr., Hollis Cotton Oil, Ice & Light Co., Hollis, Okla.

HARRISON, Edwin S. (Junior, 1905), P. O. Box 201, Evansville, Ind.

HILLYER, George, Jr. (1898; Associate 1904), Broad River Granite Co., Candler Bldg., and *for mail*, 568 W. Peachtree St., Atlanta, Ga.

JALONICK, Hartwell (Junior, 1909), Designing and Cons. Engr., Mills Bldg., El Paso, Texas.

KELMAN, John H. (1904), 194 Lefferts Pl., Brooklyn, N. Y.

KEMBLE, Parker H. (1908), Genl. Sales Mgr., Toronto Elec. Light Co., Toronto, Canada.

KING, George I. (1901), Ch. Engr., Stand. Steel Car Co., and *for mail*, 200 Brady St., Butler, Pa.

KOLLBERG, Gustaf Leonard (1910), Engr., Pumping Eng. Dept., Allis-Chalmers Co., and *for mail*, 280 31st St., Milwaukee, Wis.

LANGE, Heinrich Bartels (Junior, 1910), Am. Optical Co., and *for mail*, 37 Everett St., Southbridge, Mass.

LAVERY, George L. (1886), Lavery-Taylor Realty Co., 1122 Bryn Mawr Ave., and 5453 Kenmore Ave., Chicago, Ill.

LEWIS, David J., Jr. (1892), Sales Mgr., Lytton Mfg. Corp., 1159 Hudson Terminal Bldg., 50 Church St., New York, N. Y.

LYON, J. Lawrence (Junior, 1906), 767 Lincoln Pl., Brooklyn, N. Y.

McCOLL, J. R. (1903), Member of Firm, Ammerman, McColl & Anderson, 1330-1332 Penobscot Bldg., and Dean Engrg. Dept., Univ. of Detroit; also 9 Gladstone Ave., Detroit, Mich.

McDEWELL, Horatio S. (Junior, 1908), Allis-Chalmers Co., 71 Broadway, New York, and *for mail*, Cementon, N. Y.

McMULLIN, Frank V. (1903), 2313 Farmers Bank Bldg., Pittsburg, Pa.

MATTSSON, A. Geo. (1892), Ch. Engr., Great Lakes Engrg. Wks., and *for mail*, 199 Palmer Ave., E., Detroit, Mich.

MAYSILLES, John Henry (1901; 1910), Supt., Davenport Loco. Wks., and *for mail*, 1719 Brady St., Davenport, Iowa.

MILLER, John S. (1900; 1907), Sales Engr., Yuba Constr. Co., and *for mail*, 625 H St., Marysville, Cal.

MILLHOLLAND, William Knox (1907), Pres., W. K. Millholland Mch. Co., Industrial Bldg., 10th and Canal Sts., and *for mail*, 2857 N. Capitol Ave., Indianapolis, Ind.

MONTAGUE, Chas. Dwight (1905), 2563 Bedford Ave., Brooklyn, N. Y.

MURRIE, John L. (Junior, 1905), Ford, Bacon & Davis, 115 Broadway, New York, N. Y.

MYERS, Cornelius T. (Associate, 1908), Mech. Engr., Genl. Motors Co., and *for mail*, 127 Woodward Ave., Detroit, Mich.

NICHOLL, John Seymour (Junior, 1909), with Walter B. Snow, 170 Summer St., Boston, Mass.

NORTON, Fred Elmer (1907), Genl. Elec. Co., West Lynn, and *for mail*, 22 Atlantic St., Lynn, Mass.

O'NEIL, Frederick Wm. (1901; 1908), Mgr. of Sales, Nordberg Mfg. Co., Milwaukee, Wis.

PARK, Walter E. (1903), Box 1562, Cape Town, S. A.

PENNINGTON, James H. (1902), Supt. Constr. and Power, Am. Smelting & Refining Co., and *for mail*, 734 Roland Ave., Baltimore, Md.

POLHEMUS, Louis Edward (Junior, 1909), Mech. and Elec. Engr., Cubo Min. & Milling Co., Apartado 49, Guanajuato, Mex.

REED, William E. (1898), 71 Broadway, and *for mail*, The Van Dyck, 175 W. 72d St., New York, N. Y.

REPATH, Charles H. (1891), P. O. Box 841, Douglas, Ariz.

RIDDLE, Howard Sterling (1905), V. P., Weinman Pump Mfg. Co., Columbus, and *for mail*, Route 2, Shepard, O.

RIDGELY, Wm. Barret (1880; 1895), 1908 Q St., N. W., Washington, D. C.

RIGGS, John D. (Junior, 1892), Draftsman, O. C. P. W., and *for mail*, 422 N. Main St., South Bend, Ind.

RILEY, Robert Sanford (1906), 381 Wayland Ave., Providence, R. I.

SCHAEFFLER, Joseph C. (1900; 1904; 1907), Joseph C. Schaeffler & Co., 73 Tremont St., Boston, Mass., and 38-40 W. 32d St., also 151 W. 91st St., New York, N. Y.

SHAW, Charles H. (Associate, 1906), West. Sales Mgr., Potter & Johnston Mch. Co., 967 National Ave., Milwaukee, Wis.

SHEPPARD, John Leefe, Jr. (Associate, 1906), N. E. Engrg. Co., 50 Church St., New York, N. Y.

SICKLES, Eugene Charles (1896; 1904), Supt. Power Plants, B. & O. R. R., Central Bldg., and 844 N. Carey St., Baltimore, Md.

SMITH, Jesse M. (1883), Manager, 1891-1894; Vice-President, 1894-1896; 1899-1901; President, 1909; Life Member; Mech. and Elec. Engr. and Expt. in Pat. Causes, Rm. M-14, 220 Broadway, and 120 Riverside Drive, New York, N. Y.

SMITH, Roy B. (Junior, 1905), Asst. M. P. Inspr., Pa. Lines West, and *for mail*, 218 King Ave., Columbus, O.

STEVENS, Wm. N. (Junior, 1886), V. P., Conveying Mchy. Co., 120 Liberty St., New York, and 243 Brooklyn Ave., Brooklyn, N. Y.

SWAN, John Joseph (1899; 1909), Chicago Pneu. Tool Co., 50 Church St., New York, N. Y., and Plainfield, N. J.

SWEET, Charles E. (1907), Genl. Supt., Northway Motor & Mfg. Co., Detroit, Mich.

SYMINGTON, E. Harrison (Associate, 1903), Mech. Expt., T. H. Symington Co., Md. Trust Bldg., Baltimore, Md.

SYMONDS, Nathaniel Gardiner (Junior, 1905), Sales Engr., Westinghouse Mch. Co., 407 Traction Terminal Bldg., Indianapolis, Ind.

THORN, Charles Norman (Associate, 1910, Asst. Genl. Mgr., Charge of N. Y. Office, Allied Mchy. Co. of Am., 55 Wall St., New York, N. Y.

VAN ZANDT, Paul C. (1900; 1907; 1909), Dist. Mgr., Stephens-Adamson Mfg. Co., 1053 First Natl. Bank Bldg., Chicago, Ill.

WADLEIGH, George R. (1907), Engr., Bemis Bros. Bag Co., and 4258 Shaw Ave., St. Louis, Mo., and *for mail,* Bemis, Tenn.

WARNER, Worcester R. (1880), Manager, 1890-1893; President, 1897; Pres., Warner & Swasey Co., Cleveland, O., and *for mail,* Wilson Park, Tarrytown, N. Y.

WEGG, David S., Jr. (Junior, 1909), Telluride House, Ithaca, N. Y., and *for mail*, 16 E. Ontario St., Chicago, Ill.

WETMORE, Charles P. (1901), 518 Astor St., Milwaukee, Wis.

WHITE, Wm. M. (1907), Mgr. and Ch. Engr., Hyd. Dept., Allis-Chalmers Co., and *for mail,* A 375 Lake Drive, Milwaukee, Wis.

WILKINSON, Cecil Tom (Junior, 1908), 8 Culmington Rd., Ealing, London, W., England.

WILKINSON, Thomas L. (1894; 1905), Cons. Mech. Engr., 406 Boston Bldg., and 5833 Montview Blvd., Denver, Colo.

WILLIAMS, Alan Gillespie (Junior, 1909), 672 Eagle St., Terre Haute, Ind.

WINTERROWD, William H. (Junior, 1907), Asst. Engr., Mech. Dept., Lake Shore & Mich. So. Ry. Co., Genl. Offices, and *for mail,* 156 Carlyon Rd., Cleveland, O.

NEW MEMBERS

ARNOLD, Anthony Brown (1911), Asst. Engr., Am. Agri. Chem. Co., 92 State St., Boston, Mass.

ARTER, Wilbur D. (Junior, 1911), Asst. Engr., N. Y. C. & H. R. R. R. Co., and *for mail*, 332 W. 58th St., New York, N. Y.

BAQUET, Camille, Jr. (1911), Supt., Valley Iron Wks., Box 34, Williamsport, Pa.

BAUSCH, Carl L. (Junior, 1911), Industrial Engr., Bausch & Lomb Optical Co., Rochester, N. Y.

BAYNE, George Henry (1911), Mech. Engr., Pa. Coal & Coke Co., 17 Battery Pl., New York, N. Y.

BERRESFORD, Arthur W. (1911), V. P. and Genl. Mgr., The Cutler-Hammer Mfg. Co., Milwaukee, Wis.

BOBLETT, Kinderman M. (Associate, 1911), Radiator Expt., The Kinsey Mfg. Co., Toledo, O.

BONNETT, L. B. (1911), Civ. Service Examiner, Mech. Engr., Municipal Civil Service Com., 299 Broadway, New York, N. Y., and *for mail*, 310 W. Jersey St., Elizabeth, N. J.

BUCK, Lucien (Junior, 1911), Engr., The Champion Fibre Co., and *for mail*, Box 428, Canton, N. C.

BURROUGHS, Joseph Howell, Jr. (Junior, 1911), 226 W. 140th St., New York, N. Y.

CARISS, Carington Carysfort (Junior, 1911), Ch. Draftsman, E. Leonard & Sons, and *for mail*, 396 Glebe St., London, Ont., Canada.

COLE, Fred Baker (1911), Prin. Asst. Engr., Chas. T. Main, 201 Devonshire St., Boston, Mass.

DAVIS, Leon Keith (1911), Engr., Mfrs. Mut. Fire Ins. Co., 815 Banigan Bldg., Providence, R. I.

D'OLIER, William Livingston (1911), Pres., D'Olier Engrg. Co., 1304 Morris Bldg., Philadelphia, Pa.

FABENS, Andrew Lawrie (Junior, 1911), Apprentice Sales Dept., Aluminum Co. of Am., Pittsburg, and *for mail*, 501 Sixth Ave., New Kensington, Pa.

FINCH, Ellis Jerome (Junior, 1911), Asst. to Supt., Pittsburg Plate Glass Co., Crystal City Plant, and *for mail*, Box 736, Crystal City, Mo.

FORD, William Lucas (1911), N. E. Sales Mgr., Murphy Iron Wks. of Detroit, Mich., Rm. 520, 35 Federal St., Boston, Mass.

GILBERT, E. E. (1911), Sales Mgr., Turbine Dept., Genl. Elec. Co., Schenectady, N. Y.

GOING, Charles Buxton (1911), Managing Editor, The Engineering Magazine, 140 Nassau St., New York, N. Y.

GREENWALL, Walter L. (1911), Asst. Ch. Draftsman, Nordberg Mfg. Co., and *for mail*, 534 Logan Ave., Milwaukee, Wis.

HALL, Harris Forster (1911), Member of Firm, Wright-Hall Engrg. Co., Fisher Bldg., Chicago, Ill.

HAMMOND, Myram Hance (1911), Genl. Supt., Knickerbocker Portland Cement Co., Hudson, N. Y.

HARTWELL, Arthur Edward (Junior, 1911), Dir. Mech. Engr. and Asst. Mgr., Hartwell Iron Wks., and *for mail*, 1209 Webster Ave., Houston, Tex.

HOBBS, Franklin Warren (1911), Treas. and Exec. Officer, Arlington Mills, 78 Chauncey St., Boston, Mass.

HONYWILL, Albert William (Junior, 1911), 171 Ellsworth Ave., New Haven, Conn.

HOWELL, Sylvester S. (1911), Cons. Engr., Chamberlain & Howell, 1522 Marquette Bldg., Chicago, Ill.

HUBBARD, Carleton Waterbury (Junior, 1911), Engr., Mianus Motor Wks., Stamford, and *for mail*, Greenwich, Conn.

HUMES, W. Sharon (1911), Sales Engr., Genl. Ry. Supply Co., 531 Marquette Bldg., Chicago, Ill.

JOHNSTON, William Atkinson (1911), Assoc. Prof. of Mech. Engrg., Mass. Inst. of Tech., Boston, Mass.

KNOX, Clarence M. (Junior, 1911), Mech. Engr., 281 Wethersfield Ave., Hartford, Conn.

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BROWN, Alexander E., May 3, 1911.

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LARSON, Charles J., April 6, 1911.

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JULY–AUGUST

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

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June 28–July 1, annual convention, Indianapolis, Ind. Secy., Chas. L. Parsons, Durham, N. H.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

July 6, 7 and 8, semi-annual meeting, Chicago, Ill. Secy., W. W. Macon, 29 W. 39th St., New York.

AMERICAN SOCIETY FOR TESTING MATERIALS

June 27 to July 1, annual meeting, Atlantic City, N. J. Secy., Prof. Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

INDIANA ELECTRIC LIGHT ASSOCIATION

August 23-24, annual meeting. Secy., J. V. Zartman, Indianapolis, Ind.

THE INSTITUTION OF MECHANICAL ENGINEERS

July 24, summer meeting, Zürich and Northern Switzerland. Secy., Edgar Worthington, Storey's Gate, St. James's Park, Westminster, S. W., London, England.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION

August 15, annual meeting, Toledo, O. Secy., A. L. Woodworth, Lima.

INTERNATIONAL RAILWAY GENERAL FOREMEN'S ASSOCIATION

July 25-27, annual meeting, Chicago, Ill. Secy., L. H. Bryan, D. & I. R. Ry., Two Harbors, Minn.

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July 19, Niagara Falls, N. Y. Secy., W. H. Morton, 41 Martin Bldg., Utica, N. Y.

OHIO ELECTRIC LIGHT ASSOCIATION

July 25-28, annual meeting, Cedar Point, O. Secy., D. L. Gaskell, Greenville, O.

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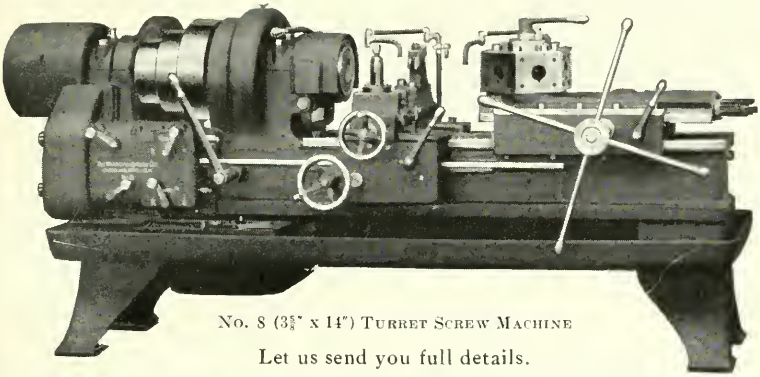

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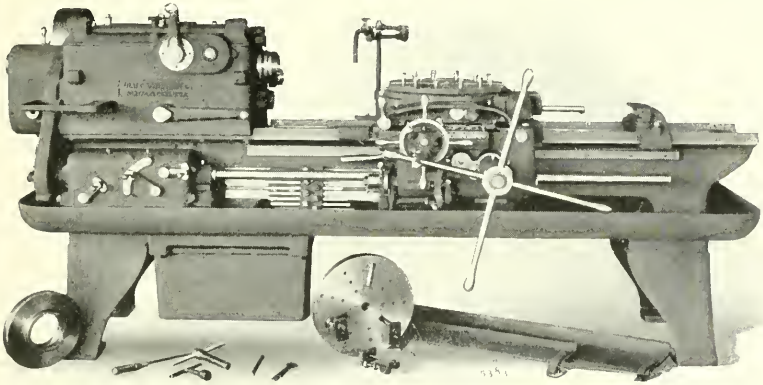

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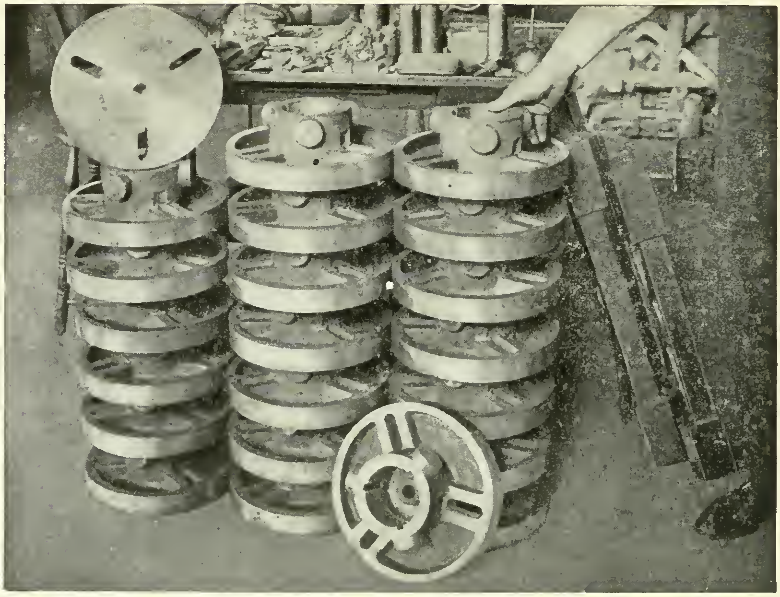

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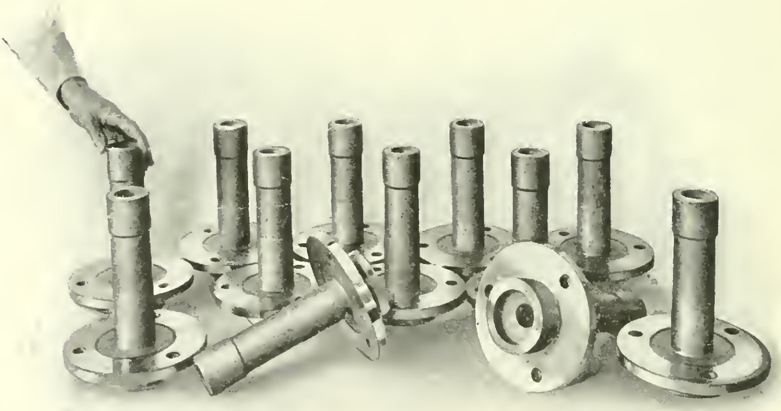

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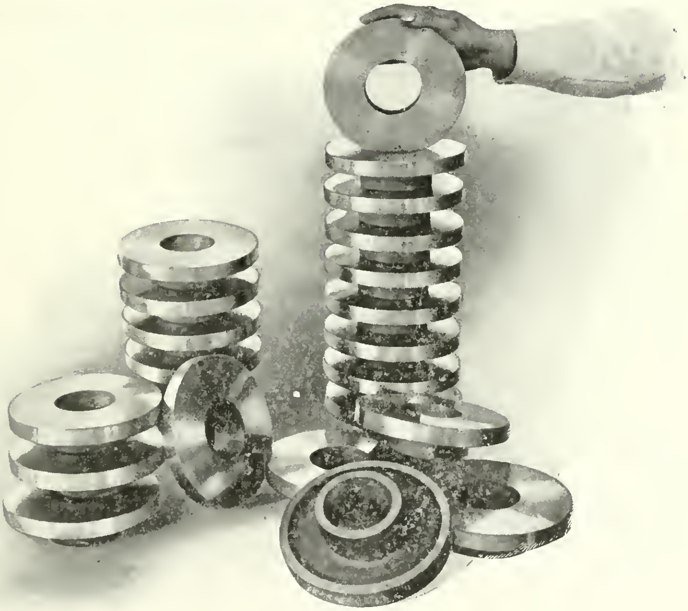

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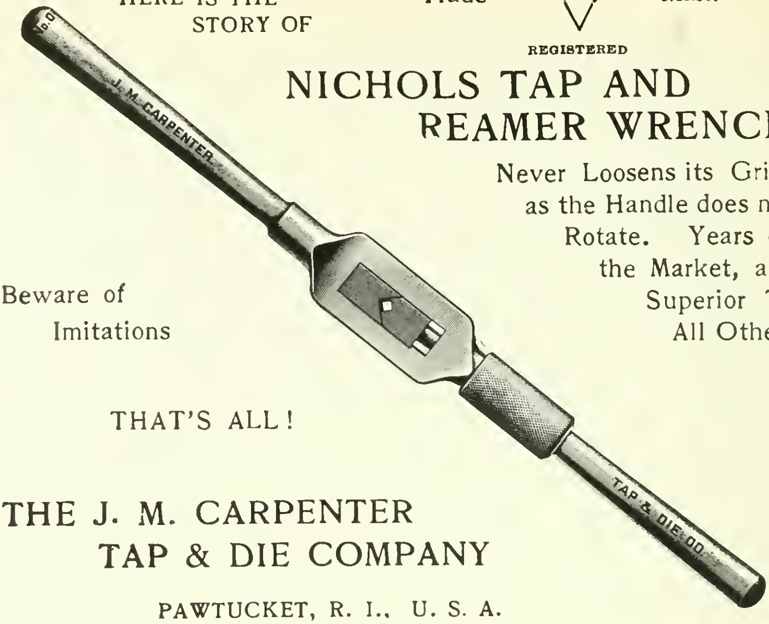

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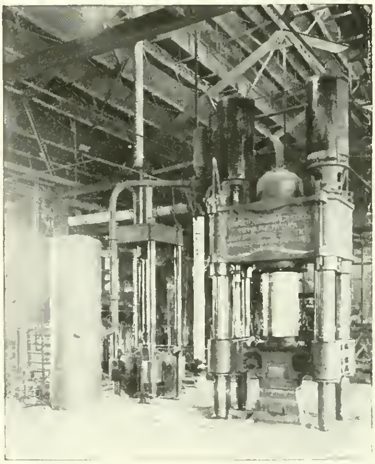

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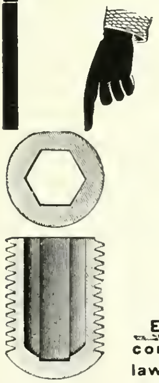

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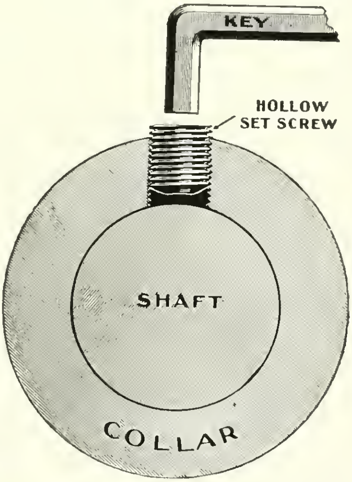

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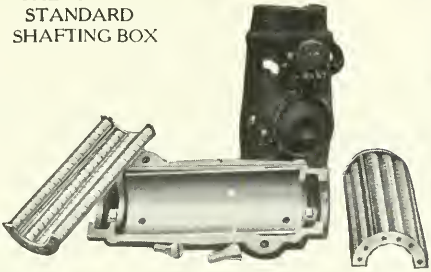
HYATT FLEXIBLE ROLLER BEARINGS



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Under all conditions there is a line of contact the full length of the roller.

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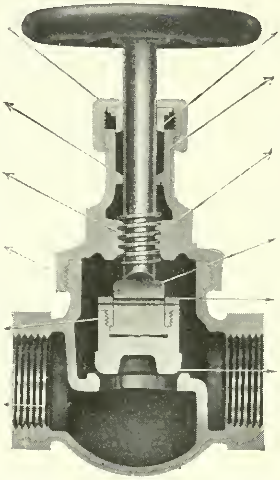
Combination Bronze Globe Valves



Stem has bearing at three points in the bonnet, steadying it centrally, causing the discs to remain at all times *central* with the seat.

Bonnet screwed on the outside of the body, fortifying the body against internal strain.

This regrinding disc can be replaced easily with the rubber disc or copper disc shown in valves at the bottom, on the right, all being renewable and interchangeable on the *same stem in the same valve.*

See the wide hexagons and the long threads.

Gland Packed.

Large Packing Box.

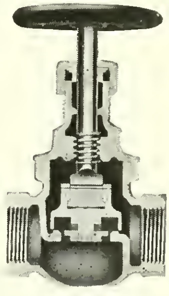
All threads engaged with bonnet when valve is closed, when you apply the most pressure and *need the most strength.*

Chamfered shoulder makes tight joint with recess in bonnet when valve is wide open, so you can repack valve when under pressure.

To regrind, a nail through this hole prevents the disc from revolving on the stem.

Regrinding disc radial where it makes contact with the seat, preventing cutting of both disc and seat. (Cut shows valve slightly open.)

For 175 pounds working pressure, each valve tested to 500 pounds.



Showing the same valve with rubber disc.

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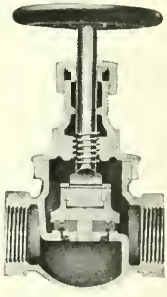

Showing the same valve with copper disc.

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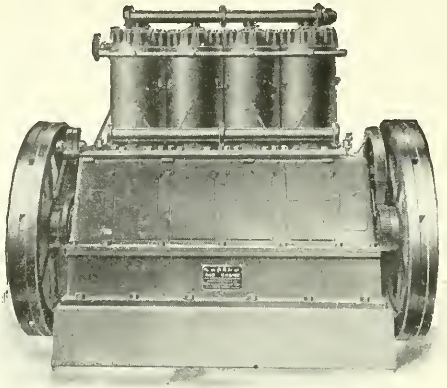

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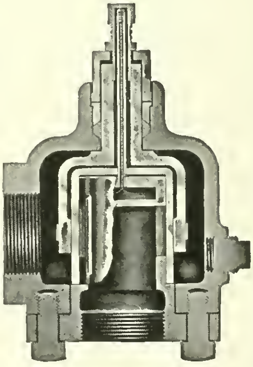

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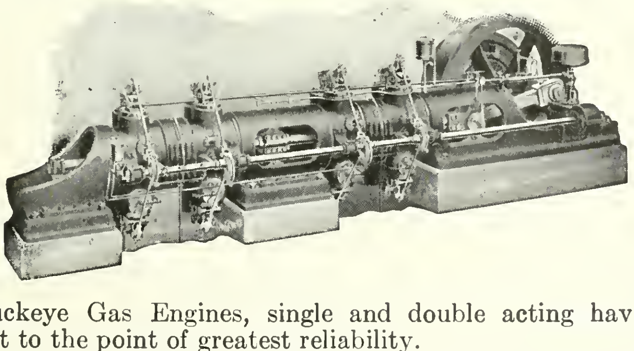

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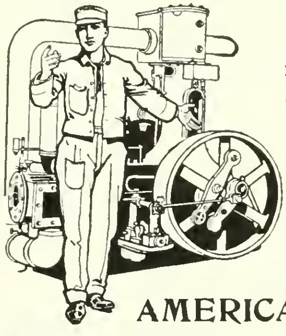

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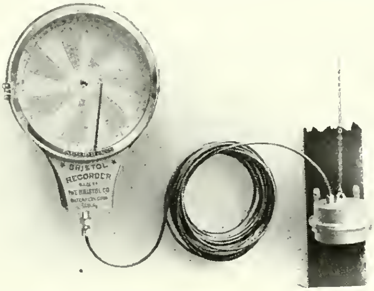

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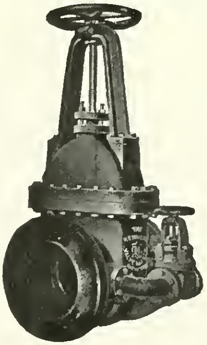

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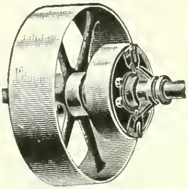

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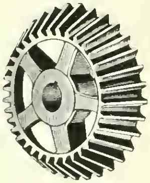

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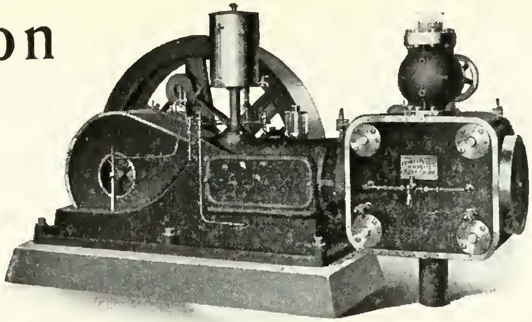

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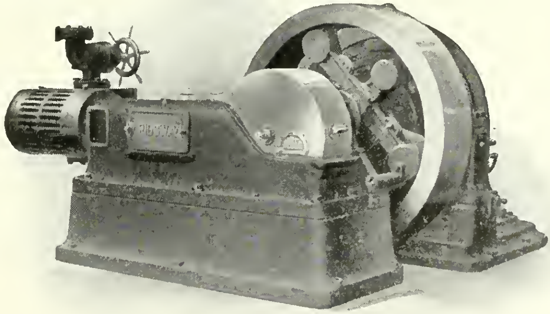

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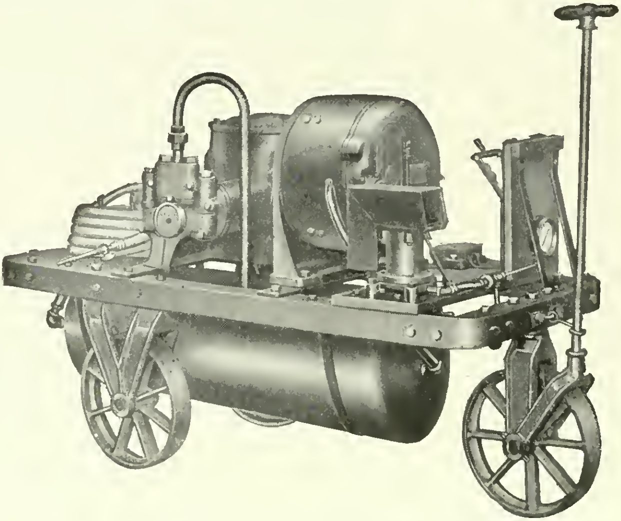

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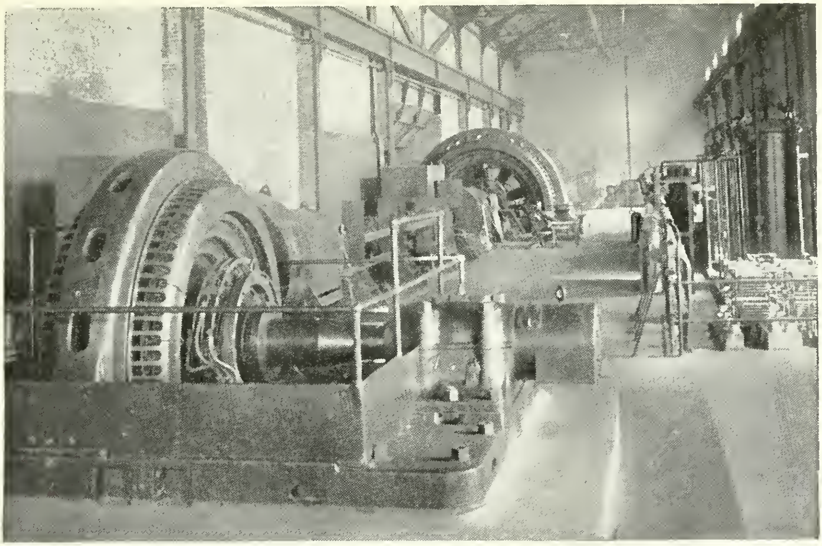

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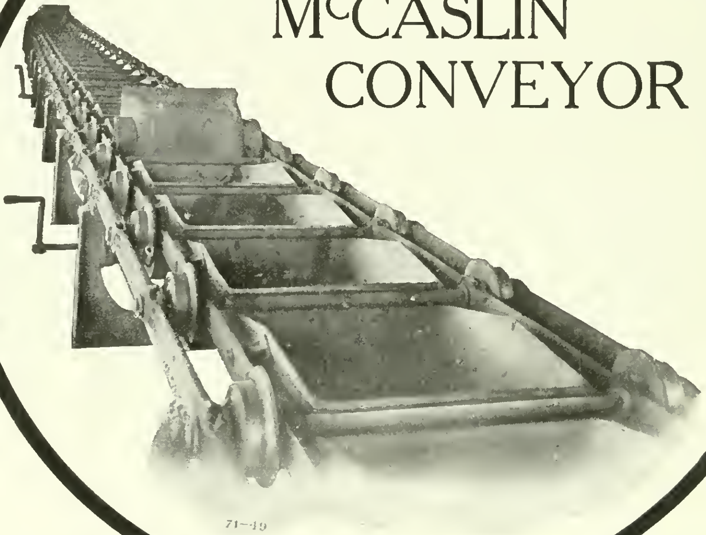

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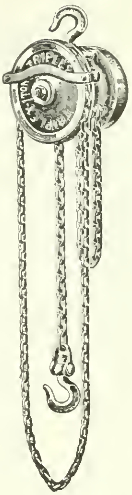

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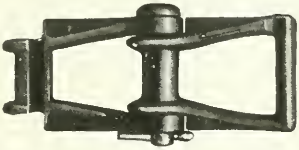

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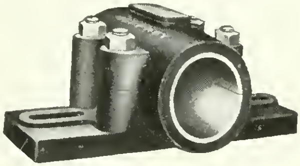

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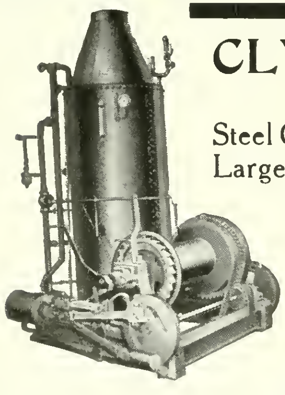

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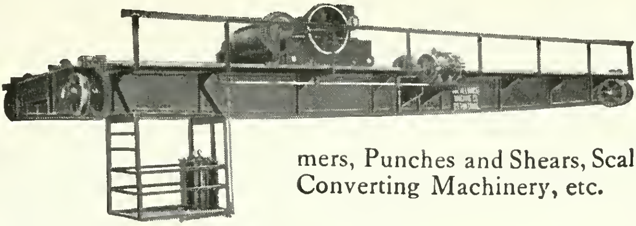

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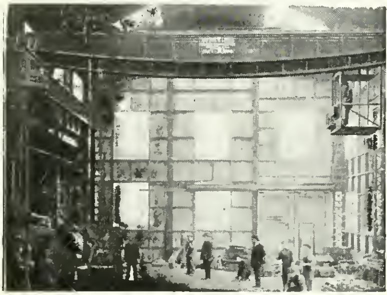

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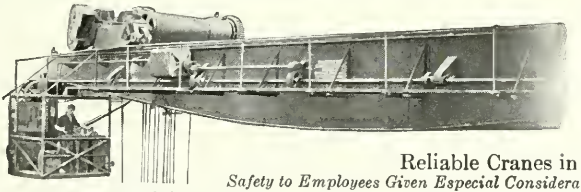

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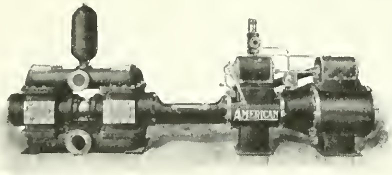

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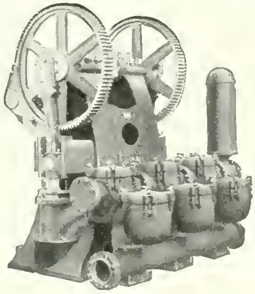

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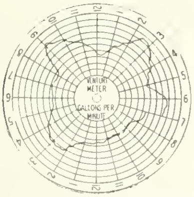

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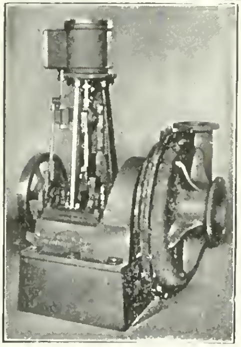

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Power Transmission

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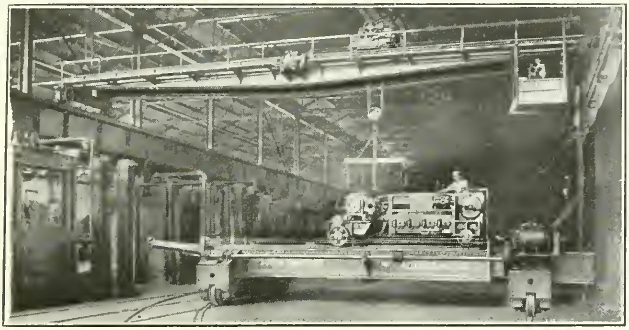

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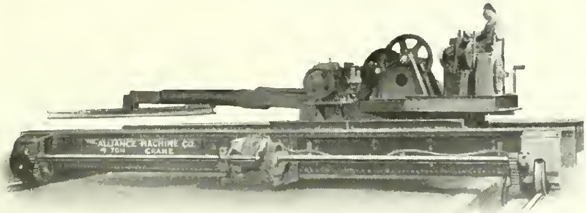
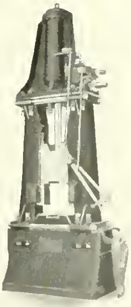
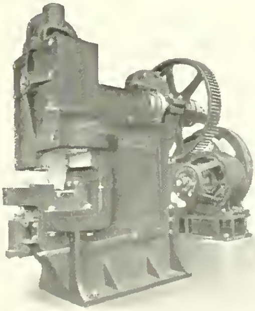


Billet Charging Machine. Floor Type



12000 lb. Steam Drop Hammer



Electric I-Beam Shear

See also following pages

THE ALLIANCE MACHINE CO.

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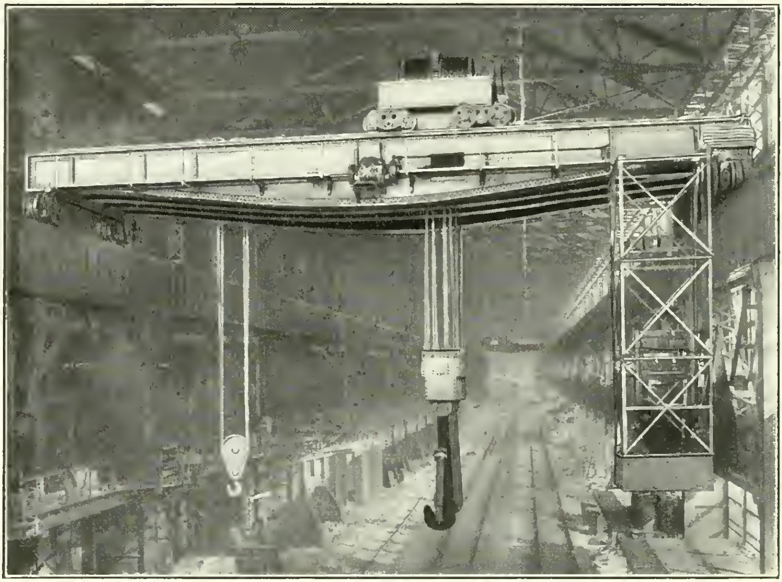

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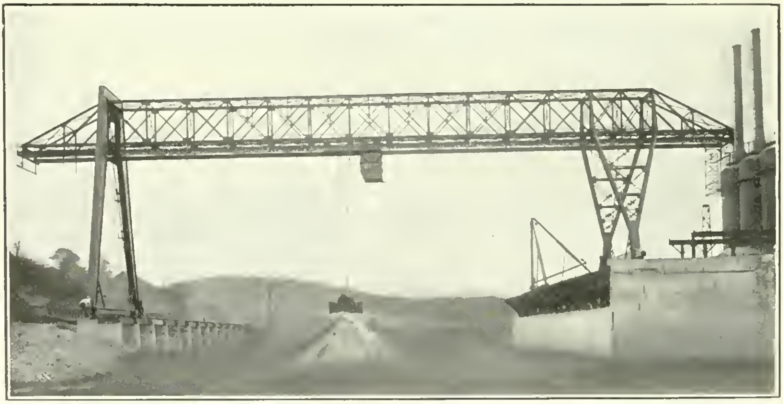

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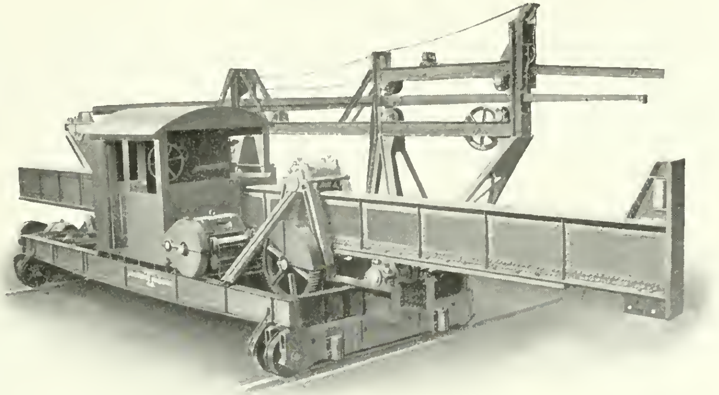

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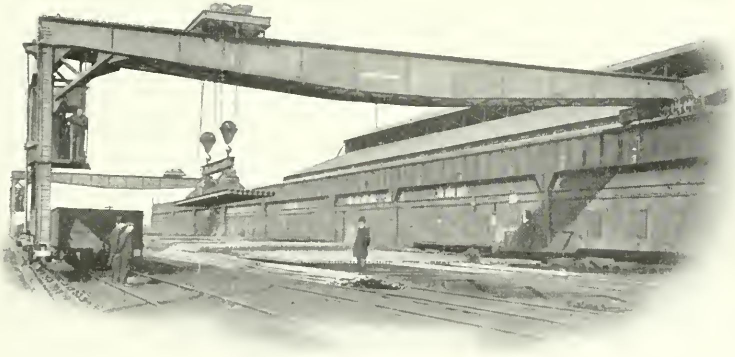


MAGNET GANTRY CRANE FOR HANDLING RAILS.

The above cut shows a single leg gantry crane equipped with special magnet for loading and unloading rails. The first day the above cranes were put in service at the plant of the Maryland Steel Company one of them unloaded a car of light rails in five minutes.

A traveling crane equipped with a magnet is absolutely the most economical way to handle material in bulk in stock yards or loading or unloading. The crane may be either standard traveling crane, single or double leg gantry or cantilever gantry, depending upon the conditions existing and we will be glad to recommend the most suitable type.

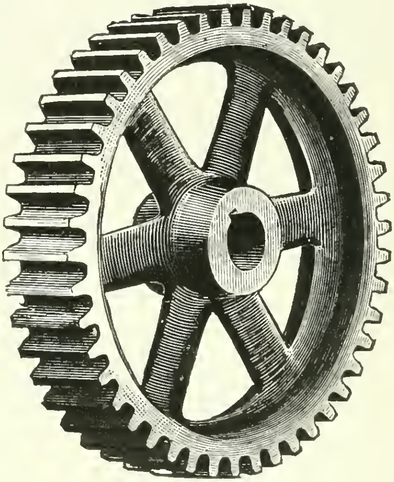
THE A. & F. BROWN CO.

ENGINEERS, FOUNDERS, MACHINISTS AND MILLWRIGHTS

172 FULTON STREET,
NEW YORK CITY

WORKS
ELIZABETHPORT, N. J.

MANUFACTURERS OF GEARS OF ALL DESCRIPTIONS, TURNED STEEL SHAFTING, PULLEYS, SPLIT PULLEYS, FRICTION CLUTCHES, SPECIAL MACHINERY, ETC.

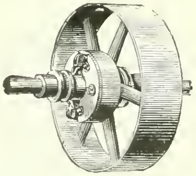


CUT GEARS

These gears are cut on the best up-to-date automatic machines obtainable, enabling this department of the shops to turn out accurately cut gears of every description and size.

MACHINE MOULDED GEARS

The Gear Department of our foundry is fitted up with the most modern gear moulding machines, enabling us to furnish machine moulded gears up to 16 feet diameter, and 25 tons in weight if in one piece, and heavier if split, or built up. These gears are much more accurate than ordinary cast gears and are of the toughest mixture of iron.



FRICTION CLUTCHES

The F. Brown Friction Clutch is simple, compact and having few small parts is not liable to get out of order; engages gradually and when thrown "in gear" has a stronger grip than any other, owing to the large friction surfaces and powerful operating device which is a combination of double ended (or right and left thread) screw and toggle joint.

SIRENS

These fog signals are used by the United States Navy and Light-house Departments, also by a number of foreign governments and many steamships. They are also in use as fire alarm signals in small towns and large manufacturing plants.

COGSWELL MILL

The problem of grinding or pulverizing many materials has been successfully solved by this machine.

SPECIAL MACHINERY

These shops are particularly well equipped for building special machinery to plans and specifications. The pattern shop, foundry and machine shops are strictly up-to-date in all particulars and equally well equipped to turn out work of the heaviest character as well as light machinery requiring first class material and workmanship and most modern tools.

Established 1854. Incorporated 1898.

THE BROWN HOISTING MACHINERY COMPANY

NEW YORK	CLEVELAND	PITTSBURGH
50 Church St.	Main Offices and Works	Frick Building

BRIDGE TRAMWAYS, FAST PLANTS, CANTILEVER AND GANTRY CRANES, LOCOMOTIVE CRANES, GRAB BUCKETS, TRAVELLING CRANES, JIB AND PILLAR CRANES, CRABS, WINCHES, ETC.

BRIDGE TRAMWAYS, FAST PLANTS, CANTILEVER AND GANTRY CRANES

The "Brownhoist" machines are designed along strict engineering lines which give them the lightest structure possible, while still possessing strength and durability. This gives them several great advantages over other machines, such as less motive power required; faster work; less surface offered to wind pressure which is a large factor in this class of machines; and greater flexibility, which reduces the strain and wear on the machines. The machines are equipped either with the trolley, operated from the engine house, or with the man trolley. Electric power is generally used. Either the grab bucket, bottom block, hook, or any special carrying device can be used. The machines are made in various styles and sizes, to conform to the purchaser's conditions.

LOCOMOTIVE CRANES

We make the four wheel and the eight wheel cranes; for any gauge track; of various capacities; the power is either steam, electrical, or from internal combustion engines; and one man operated as the operation is very simple. By means of the Grafton patented friction slip-ring, the rotating mechanism is relieved of all strains due to a sudden stop in rotating. The travel, hoisting, and rotating are accomplished through friction clutches. Rotating in either direction is done without reversing the engines. The lowering of the load is controlled by a friction band brake. Our cranes are equipped with the steam brake, which is necessary for good working results. They also have the standard car fittings, which enable them to do switching service. Our eight wheel cranes are also equipped with standard M. C. B. trucks and fittings, thereby making it possible for them to travel in trains. The cranes can use either the grab bucket, bottom block, or lifting magnet, all interchangeable in a short time.

GRAB BUCKETS

The Brownhoist patented grab bucket has a very high efficiency in the handling of all loose material, such as ore, coal, stone, sand, etc. The spread of the spades is very wide. The entire weight of the bucket rests upon the cutting edge of the two spades. This eliminates the necessity of dropping the bucket with force onto the material to insure its filling. The bucket is filled by a scraping motion of the spades, and it will not begin to rise until the spades are entirely closed. This results in a full load every time. The sheaves are well guarded from the material. They are bronze bushed, and are so arranged as to avoid any twisting of the ropes.

We also design and manufacture hand travelling cranes, pillar cranes, jib cranes, furnace hoists and tops, crabs and winches, tubs, ore and coal tipples, transfer cars, cableways, locomotive coaling stations, pig iron breakers, and storage bins for ore, coal, coke, etc. Also "ferro-in-clave," a patented combined reinforcement and centering for concrete floors, roofs, sides, stairs, bins, linings, etc.

Catalogs furnished on request.

H. W. CALDWELL & SON COMPANY

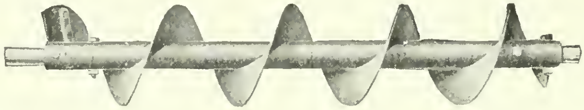
CHICAGO, ILLINOIS

ELEVATING, CONVEYING AND POWER TRANSMITTING MACHINERY, MACHINE MOLDED AND PATTERN GEARS 1″ TO 6″ PITCH, CAST IRON SEMI-STEEL AND STEEL, LINK CHAIN BELTING, SPROCKET WHEELS, PULLEYS, FLY WHEELS, ROPE DRIVES, BEARINGS, COUPLINGS, FRICTION CLUTCHES, ETC.

Catalogue No. 34 contains complete lists

HELICOID CONVEYOR

Sole Manufacturers of "HELICOID CONVEYOR."
Made of one Continuous Strip of metal without lap or rivet.
Mounted on standard and extra heavy pipe or solid shaft.



LIST OF SIZES WITH DIMENSIONS

Standard Gauge Helicoid on regular size pipe

Diameter	Standard Lengths, Feet	Diameter of Couplings, Inches	Inside Diameter of Hollow Shaft, Inches	Outside Diameter of Hollow Shaft, Inches
3		3/4	1	1 5/16
4	8	1	1 1/4	1 5/8
5	8	1	1 1/4	1 5/8
6	10	1 1/2	1 3/4	2 1/8
7	10	1 1/2	1 3/4	2 1/8
8	10	1 1/2	2	2 3/8
9	10	1 1/2	2	2 3/8
9 Sp'cl	10	2	2 1/2	2 7/8
10	10	1 1/2	2	2 3/4
12	12	2	2 1/2	2 7/8
12 Sp'cl	12	2 7/16	3	3 1/2
14	12	2 7/16	3	3 1/2
16	12	3	3 1/2	4

Heavy Helicoid on regular size pipe or solid shaft

Diameter, Inches	Standard Lengths, Feet	Thickness of Flight Next Pipe, Inches	Thickness of Flight, Outer Edge, Inches	Inside Diameter Pipe, Inches	Diameter Couplings Inches	If Made on Solid Shaft, Diameter Shaft, In.
4 x	8	3/16	.11	1 1/4	1	1 5/8
6 x	10	1/4	.125	1 3/4	1 1/2	2 1/8
6 xx	10	3/8	.2	1 3/4	1 1/2	2 1/4
7 x	10	1/4	.141	1 1/2	1 3/16	1 15/16
9 x	10	3/8	.172	2	1 1/2	2 3/8
9 xx	10	3/8	.19	2 1/2	2	2 15/16
10 xx	10	3/8	.19	2 1/2	2	2 15/16
12 x	12	3/8	.17	2 1/2	2	2 15/16
12 xx	12	3/8	.18	3	2 7/16	3 7/16
12 xxx	12	1/2	.25	3 1/2	3	3 15/16
14 xx	12	7/16	.234	3 1/2	3	3 15/16
16 xxx	12	1/2	.25	4	3	4 7/16

CLYDE IRON WORKS

29th AVENUE, WEST, AND MICHIGAN ST.
DULUTH, MINN.

HOISTING ENGINES, DERRICKS AND DERRICK FITTINGS, ELECTRIC HOISTS BELT DRIVEN HOISTS, AUTOMATIC BUCKETS

CLYDE HOISTING ENGINES AND BOILERS

Our product is used for all kinds of Contractor's work, Dredging, Pile Driving, Railroad and Bridge Building, Quarries and general hoisting purposes. We also make a specialty of engines for skidding and rolling logs, and for general logging operations.

All our engines are thoroughly tested under steam as well as by the usual hydrostatic test. All parts are made from standard jigs and templates and are absolutely interchangeable.

ONE, TWO, THREE, AND FOUR DRUM HOISTING ENGINES

In our fifty-six page catalog we illustrate the various types of our standard engines with single or multiple drums, and single or double cylinders. These hoisting engines are regularly built with or without boiler, winch and sheave heads, and reversing gear.

DERRICKS AND DERRICK FITTINGS

In our special Derrick Catalog D, we illustrate and list a complete line of timber derricks and fittings. All usual conditions can be met with some one of our standard styles, but we are prepared to build derricks for any special conditions that may arise. For this purpose we maintain a force of draftsmen and engineers who are specialists in this line, and their experience of many years is at the disposal of our customers.

Clyde Derricks are designed with great care to withstand violent strains. Every possible point of weakness both in the fittings and in their action on the timbers, has been guarded against and we claim our fittings to be the strongest on the market for the size of timbers for which they are intended.

Following is a partial list of our standard styles of derricks:

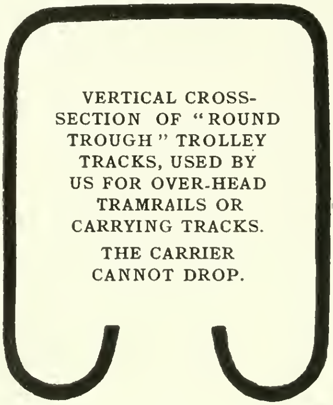
Standard Guy Derricks
Half Hand Power Guy Derricks
Hand Power Guy Derricks
Clam Shell Guy Derricks
Standard Stiff Leg Derricks
Half Hand Power Stiff Leg Derricks
Hand Power Stiff Leg Derricks
Clam Shell Stiff Leg Derricks
Full Circle Stiff Leg Derricks
Self-Propelling Derrick Cars
Self-Contained Portable Derrick

We also manufacture Automatic Clam Shell, and Orange Peel Grab Buckets, and the Clyde Self Dumping Bucket. Catalogs on request.

THE COBURN TROLLEY TRACK MANUFACTURING CO.

HOLYOKE, MASSACHUSETTS

OVERHEAD TRAMRAILS, TRAVELLING CRANES, ELECTRIC AND PNEUMATIC HOISTS, DOOR HANGERS, FIRE SHUTTERS, FIRE ESCAPES, ETC.



VERTICAL CROSS-SECTION OF "ROUND TROUGH" TROLLEY TRACKS, USED BY US FOR OVER-HEAD TRAMRAILS OR CARRYING TRACKS.

THE CARRIER CANNOT DROP.

COBURN OVER-HEAD CONVEYING SYSTEM

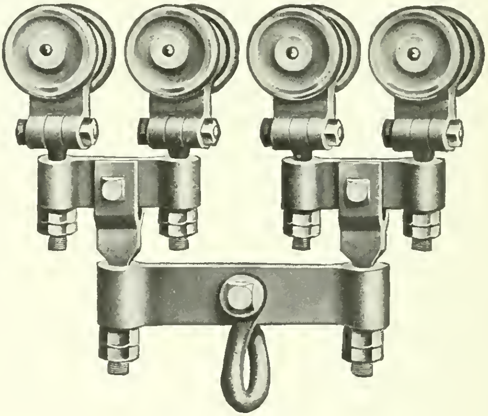
The uses of Coburn Over-head Conveying systems are so various that it is quite impossible to enumerate them all. —They can be used anywhere that heavy material has to be handled—Coal to the boiler room—Ashes and cinders to the dump head—Iron in foundry and machine shops—etc.,—etc.

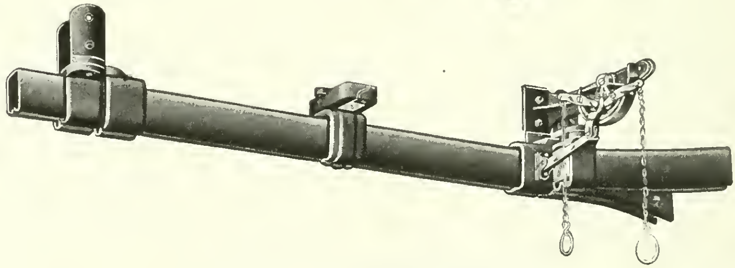
Besides the enclosed type of track, we manufacture a complete line of Overhead I Beam track, carriers, switches, etc.

We furnish free of cost estimates on all this class of work on receipt of detailed information as to requirements. Our #35 catalogue is free for the asking.

SWINGING PENDANT DOUBLE CARRIERS

A typical Coburn Carrier which can be equipped with either roller or ball bearings, and so constructed as to move around the smallest curves with the greatest ease.





REGULAR TONGUE SWITCH

No matter how complicated your system may be, we can make satisfactory arrangements for the switches—Our switches are absolutely safe—They cannot under any conditions drop the load.

DETROIT OAK BELTING CO.

DETROIT, MICHIGAN

DETROIT LEATHER BELTING

BELT MAKER'S TOOLS, LEATHER BELT CEMENT

All "Detroit" belting is manufactured from leather butts tanned exclusively for belting purposes by the slow process of pure oak bark tanning. Hides are selected under rigid specifications as to the time of year when they were removed from the cattle, the manner of conducting operations in the tan yard, nature of bark used etc., thus guaranteeing a high class and uniform product.

We manufacture five grades of belting as follows:

WOLVERINE PLANER

This is guaranteed water proof belt, made only in single thickness, and with special laps for small pulleys. The leather used is extremely heavy, and is submitted to a special currying and stretching process which adapts it to very severe service, on planers and other high-speed machinery.

NAIAD

Our "Naiad" brand of belting is guaranteed to be absolutely waterproof, and cut from the center portion of No. 1 belting butts. It is made in various weights to suit the special conditions under which the belt is proposed to run. Special Doubles for heavy planers, blowers and motorcycles.

BEST GRADES

This belt is made to give long life and great durability under the most severe conditions. Cut entirely from center portion of butt. Made in four weights as follows:

Heavy Single,—For general use where single belt of high grade quality and heavy weight is required.

Medium Single,—For general use where a medium weight single belt is required. Especially suitable for small pulleys at high speed.

Heavy Double,—Recommended for places where pulleys are large, and excessive horsepower demanded for width of pulley surface.

Medium Double,—Recommended for large motor drives, saw mills, cement machinery and other heavy service, where difference in diameter of pulleys is considerable. This is our general service weight.

DETROIT VELOCITY DOUBLE

This belt weighs 23 to 26 ounces per square foot according to width. Recommended for heavy lathe work, motors, flour mill rollers, wood working machinery, etc. This belt is not made of shoulder stock, but is strictly center cut.

KING

Made of selected side stock in both single and double, and put through the same process of manufacture as our more expensive grades. This is a Short Lap belt at a moderate price and will be found very satisfactory for ordinary service.

We also make to order a single and double belt of shoulder stock, weighing about 12 ounces per square foot single. Not made over 6″ wide. This is branded "Standard."

THE CONVEYING WEIGHER CO.

90 WEST STREET, NEW YORK, N. Y.

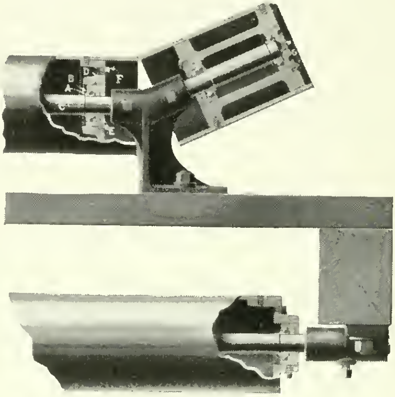
BALL BEARING BELT CONVEYORS, CONTINUOUS AUTOMATIC SCALES FOR BELT AND OTHER CONVEYORS, CONVEYING AND HOISTING MACHINERY, COMPLETE MATERIAL HANDLING PLANTS, TRUMP MEASURING AND MIXING MACHINES, TRUMP CONCRETE MIXERS, PEAT DIGGING, AND SCRAPING MACHINERY.

BALL BEARING BELT CONVEYORS

We illustrate herewith the construction of ball bearing troughing and return idlers for belt conveyors. It is guaranteed that if a belt conveyor running level be equipped with these idlers, there will be a saving of 40% in power required. These idlers having felt oil-retaining washers need to be lubricated only once in two years.

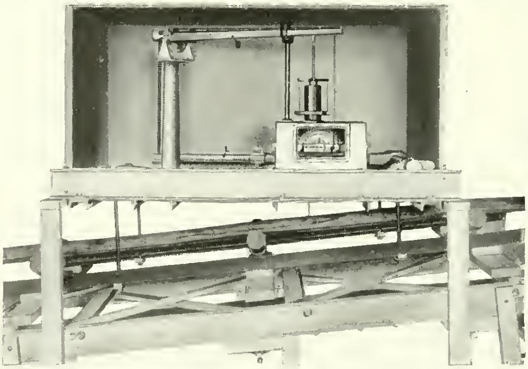
A Hardened steel "Cone," fitted on turned steel shaft
B Pressed steel "Ball Retainer"
C Turned steel shaft, set screwed in Idler brackets
D Oiled washer of felt or carded wool
E Hardened steel "Plug," screwed into pulley hub
F Brass plug for lubrication
G Lock screw to prevent hardened plug from turning

"Conweigh" Ball Bearing, troughing, and return idlers for belt conveyors (patents pending).



THE MERRICK CONVEYING WEIGHER

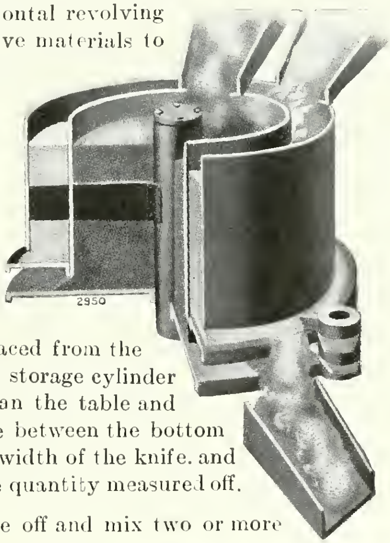
This device records the weight of material handled on belt conveyors, bucket conveyors, cable railways and over head trolleys or telphers. The weigher consists of a pair of weighing levers and a steelyard of special design so that a short section of the conveyor can be suspended from the weighing levers. The extreme end of the steelyard is connected with a totalizing mechanical integrator which derives its other factor from the travel of the conveyor by means of suitable gearing from a bend pulley on the return belt, or a sprocket wheel if on a bucket conveyor. This integrator continuously totalizes the product of two quantities, one proportional to the weight of material suspended and the other to the travel of this material. The result therefore represents the total weight of material and is plainly indicated by a register.



View of Belt Conveyor. Front Sheet of Casing Removed.

THE CONVEYING WEIGHER CO.

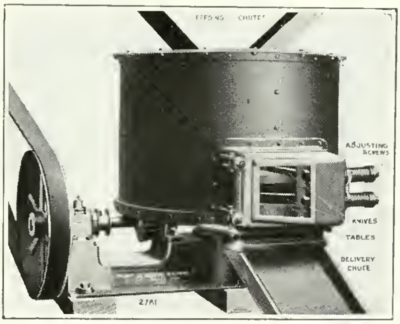
THE TRUMP MEASURING AND MIXING MACHINE



Consists of one or more horizontal revolving tables on which rest the respective materials to be measured, and for each table a stationary knife set just above the table and pivoted on a vertical shaft outside the circumference. The knifes can be adjusted to extend the proper distance into the material and peel off at each revolution of the table a certain amount which falls into the chute.

The material peeled off is replaced from the supply contained in a bottomless storage cylinder somewhat smaller in diameter than the table and revolving with it. The distance between the bottom of the cylinder and the table, the width of the knife, and the depth of its cut, determine the quantity measured off.

When it is desired to measure off and mix two or more materials, the machines are made with two or more tables set one above the other, and mounted on the same spindle so that they revolve together. Each cylinder has its own storage cylinder above it, the cylinders being placed one within the other as shown in the illustration below. Each table has its own knife and adjusting mechanism, which *enables the user to vary at will the percentage of each material in the mixture.*



The Trump Two-Material Measuring Machine
Patented

The materials flow together in small streams into a common chute, and the particles become thoroughly mixed, each infinitesimal amount of one ingredient being accompanied by the proper amounts of the other ingredients.

This device has been very successfully applied to concrete mixing, one result of which is The Trump Portable Concrete Measuring and Mixing Machine as here illustrated.

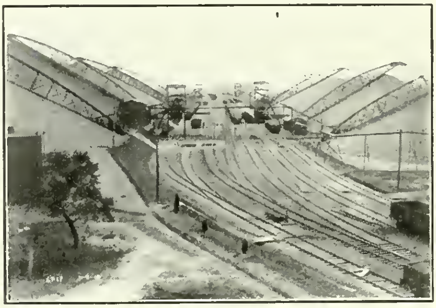
The Trump Portable Concrete Mixer

THE J. M. DODGE COMPANY

NICETOWN STA., P. & R. RAILWAY
PHILADELPHIA, PA.

The Dodge System of storing anthracite coal, Long Radius Revolving Cranes, Bridge Tramways, Direct Unloaders, Smith Box Car Loaders, Endless Cable Hauls for railroad cars, Telpherage. Designers and Builders of Locomotive Coaling Stations and Retail Coal Pockets in wood, steel, and reinforced concrete.

HANDLE COMPLETE CONTRACTS:
FOUNDATIONS, BUILDINGS, AND MACHINERY



THE DODGE SYSTEM OF STORING ANTHRACITE COAL (PATENTED)

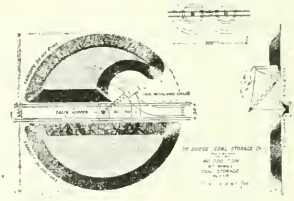
Capacity of piles from 15000 to 60000 tons. Two trimming machines and one reload-machine between piles constitute one group. Its effectiveness is due to simplicity of design, mechanical efficiency, minimum breakage, and low cost of handling.

BRIDGE TRAMWAYS AND DIRECT UNLOADERS

Complete installations of all types of Bridge Tramways and Direct Unloaders for high speed operation and maximum efficiency. Special attention given to the handling, storing and preparation of coal on docks.

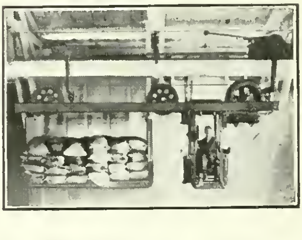
LONG RADIUS REVOLVING CRANES FOR CIRCULAR STORAGE AND COALING STATIONS (PATENTED)

Suitable for storage capacities from 6000 to 40000 tons, and handling capacities from 40 to 200 tons per hour. This is the cheapest storage system for large bodies of bituminous coal or crushed stone, and combines low cost of handling with low investment cost. The crane can also be used for filling an elevated pocket for coaling locomotives, or for retail trade.



TELPHERAGE FOR FREIGHT HANDLING

Runs on top of mono-rail, permitting safest and simplest design of trolleys, combined with flexibility and smooth running at high speeds. Especially adapted for handling freight in railroad terminals and steamship piers. Special attention given to these problems.

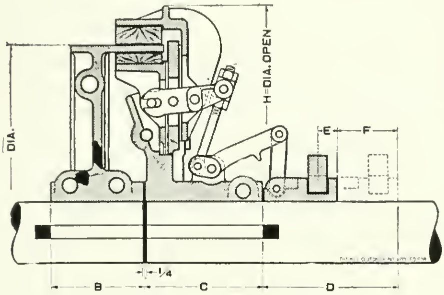


THE HILL CLUTCH CO.

CLEVELAND, O.

New York Sales Office, 50 Church St.

A COMPLETE LINE OF POWER TRANSMISSION MACHINERY FOR BELT AND ROPE DRIVES, INCLUDING THE WELL KNOWN PATENTED HILL FRICTION CLUTCH (SMITH TYPE) AND COLLAR OILING BEARINGS, BRIEFLY DESCRIBED BELOW

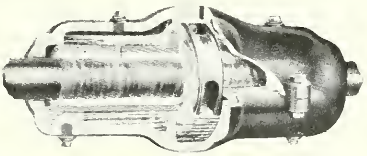


No. HP at 100 R.P.M. *	Equivalent Shaft Diam.	Maximum Stand. Bore	Extreme Bore of Mech.	Space on Shaft B	C	D	H
9	$1\frac{3}{16}$	$2\frac{3}{4}$	$3\frac{1}{2}$	3	$4\frac{1}{8}$	5	15
12	$1\frac{15}{16}$	$3\frac{1}{4}$	4	$3\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$	$17\frac{1}{4}$
15	$2\frac{3}{16}$	$2\frac{1}{2}$	$4\frac{1}{2}$	4	5	$5\frac{1}{4}$	20
20	$2\frac{7}{16}$	3	5	$4\frac{1}{2}$	$5\frac{5}{8}$	$7\frac{1}{4}$	$22\frac{1}{2}$
27	$2\frac{11}{16}$	4	$5\frac{1}{2}$	5	$6\frac{3}{8}$	$7\frac{1}{2}$	$24\frac{3}{4}$
35	$2\frac{15}{16}$	4	6	$5\frac{1}{2}$	$7\frac{1}{8}$	8	$27\frac{1}{2}$
45	$3\frac{3}{16}$	$4\frac{1}{2}$	7	6	$7\frac{1}{2}$	$8\frac{1}{2}$	$29\frac{1}{2}$
60	$3\frac{7}{16}$	$4\frac{1}{2}$	7	6	$7\frac{1}{2}$	$8\frac{7}{8}$	$29\frac{1}{2}$
75	$3\frac{11}{16}$	5	$7\frac{1}{2}$	$6\frac{3}{4}$	8	$8\frac{3}{4}$	33
90	$3\frac{15}{16}$	5	8	7	$8\frac{1}{2}$	$9\frac{5}{8}$	$36\frac{1}{2}$
110	$4\frac{3}{16}$	$5\frac{1}{2}$	9	$7\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{1}{2}$	41
140	$4\frac{11}{16}$	6	10	8	$9\frac{3}{4}$	$10\frac{7}{8}$	46
175	$4\frac{15}{16}$	6	11	9	11	11	50
230	$5\frac{1}{2}$	$6\frac{1}{2}$	12	10	12	11	57
350	6	7	12	10	12	11	57
480	7	$7\frac{3}{4}$	14	$11\frac{1}{4}$	14	12	64
625	$7\frac{1}{2}$	9	16	13	17	14	72
875	$8\frac{1}{2}$	$10\frac{1}{2}$	18	15	18	17	86
1300	10	12	18	18	20	20	95

The Smith Type of Hill friction clutches are built in 19 sizes ranging in capacity from 9 to 1300 horse power at a 100 R. P. M., and have 3, 4 and 6 arms according to their capacity. The friction surfaces are wood against iron, which is a combination offering great frictional resistance and the shoe area is exceptionally large. The action of the clutch mechanism is positive, no springs being used. The sectional view shows the toggle connection from the cone to the jaws, which positively releases, as well as engages the friction surfaces.

A noteworthy feature in the design of this clutch is that any working part, including the inside jaws, may be removed parallel to the shaft from the mechanism side. This can be done without disturbing the main spider casting or pulley, as bolted gib guides secure the inner and outer jaws to the spider as shown in the illustration. The clutch pulleys are mounted upon split removable sleeves, babbitted or bronze lined as specified, which can readily be replaced without disturbing the pulley or clutch.

HILL COLLAR OILING BEARINGS



In the Hill Collar Oiling bearings instead of depending upon a loose ring or chain for conveying oil to the journal, a fixed collar is employed. Oil stored in large reservoirs in the bottom of bearing is continuously and positively elevated to the top reservoirs by the means of a heavy split collar clamped to the shaft. From the upper reservoirs the oil flows by gravity over the entire bearing surface.

Three or four revolutions of the shaft and the bearings are flooded.

It is not only in the positive and copious means of oiling that the Collar Oiling bearing gains in efficiency, for the collar also serves as a thrust collar and operates in a bath of oil and thrusts against babitted seats. On this account no outside collars are required unless the end thrust is extremely severe. All other types of bearings require outside shaft collars which bear against iron with no lubrication.

THE
ELECTRIC CONTROLLER & MFG CO.

CLEVELAND, OHIO

LIFTING MAGNETS; THE DINKEY VENTILATED CONTROLLER; ELECTRIC BRAKES. MAGNETIC SWITCHES; MOTOR STARTERS; LIMIT STOPS; ARC WELDERS; CRANE FITTINGS; KNIFE SWITCHES; FLEXIBLE COUPLINGS; ELECTRIC FAULT FINDERS

TYPE S. A. LIFTING MAGNET

The magnet case is a single casting of heavy annealed special steel. The magnet is suspended by a three point chain suspension, the chains engaging heavy lugs cast integral with the magnet case.

Heavy ribs increase the strength and stiffness of the magnet case, increase the magnetic cross-section and exposed radiating surface, and protect the bolts which clamp the outer pole shoe in place.

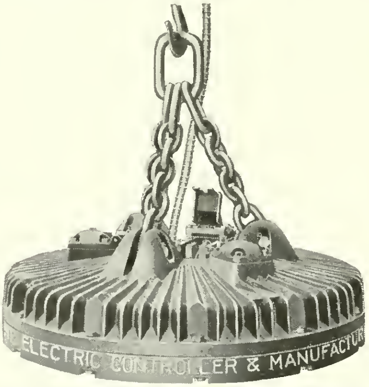
The pole surfaces of the magnets are provided with renewable shoes of exceptional thickness and the wearing face between the poles is made of manganese steel. Pole shoes and manganese steel bottom plate can be removed and replaced in the field.

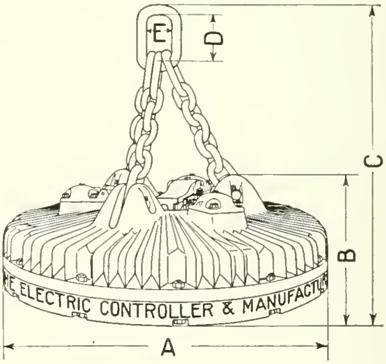
An air space is provided between the outer manganese steel bottom plate and an inner plate, so that shocks received by the bottom plate are transmitted to the heavy steel frame of the magnet and not to the winding.

No combustible material enters into the construction of the magnet coil, and it may be left across the line at full voltage without injury.

The coil or winding of the magnet is impregnated with an elastic, moisture repellant insulating compound which renders the coil proof against injury from moisture or damp air.

All parts are made to jig and are strictly interchangeable.





Type No. of Magnet	Dimensions in Inches					Net Weight lbs.	Shipping Weight lbs.	Current required Amperes at 220 volts	Average Lifts for various Marerials in lbs.						
	A	B	C	D	E				Ingots	Billets	Slabs	Pig Iron	Boiler Pl. Scrap	Junk Dealer's Scrap	Skull Cracker Balls
3	36	$14\frac{7}{16}$	$41\frac{1}{2}$	$7\frac{1}{4}$	4	2100	2250	11	6000	20000	20000	700	600	360	12000
4	$42\frac{3}{4}$	$16\frac{7}{8}$	$44\frac{3}{4}$	$7\frac{1}{4}$	4	3250	3400	27	6000	32000	32000	1200	1100	600	20000
5	$52\frac{1}{2}$	$17\frac{1}{8}$	$45\frac{3}{8}$	8	5	4800	5100	38	8000	42000	42000	1800	1500	800	20000
6	$64\frac{3}{4}$	$18\frac{3}{8}$	$50\frac{1}{8}$	8	5	6600	6850	47	16000	50000	50000	2300	2100	1000	20000

FORM H DYNAMIC BRAKING DINKEY CONTROLLER

The form H controller is a modification of the standard Dinkey Ventilated Controller in combination with two magnetic switches.

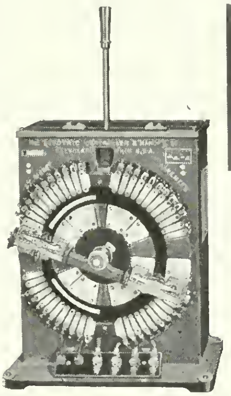
In connection with the series wound motors generally used for hoisting service the form H is a perfect hoist controller because it operates the motor as a series motor in hoisting and converts it into a shunt motor in lowering.

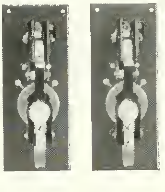
No mechanical or lowering brake is required.

This controller is operated exactly like the standard Dinkey or any other lever type reversing controller. It is designed to control a series wound motor, but will satisfactorily operate a compound motor as well, and requires no additional skill on the part of the operator.

Lowering is accomplished either by power or dynamic braking, depending on whether or not the load is sufficiently heavy to overhaul the motor and driving mechanism. The speed of any load can be controlled with a degree of fineness not otherwise obtainable and the operator need not know whether the load is being lowered by power or dynamic braking.

Form H Controllers are furnished with Type S. Magnetic Switches and in sizes from 1 to 100 h.p. inclusive, either 220 or 550 volts, and 1 to 50 h.p. 110 volts as indicated below.





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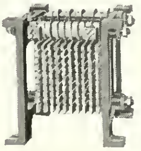
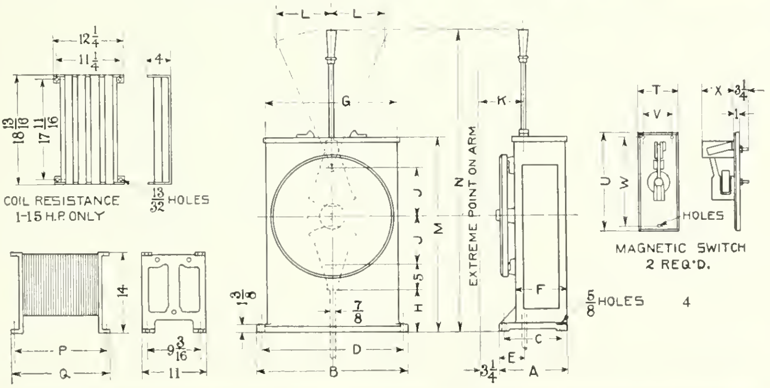




Horse Power			Dinkey Ventilated Controllers												
110 V	220 V	550 V	A	B	C	D	E	F	G	H	J	K	L	M	N
1-15 16-25	1-15 16-25	1-15 16-25	$11\frac{7}{8}$	$26\frac{5}{8}$	$9\frac{7}{8}$	$24\frac{5}{8}$	$4\frac{3}{8}$	9	$23\frac{1}{8}$	$6\frac{3}{4}$	$8\frac{1}{2}$	$7\frac{5}{8}$	$9\frac{1}{4}$	$34\frac{1}{4}$	$52\frac{1}{4}$
26-50	26-50	26-50	$15\frac{7}{8}$	$29\frac{3}{4}$	$13\frac{7}{8}$	$27\frac{3}{4}$	$4\frac{7}{8}$	$12\frac{7}{8}$	$26\frac{1}{8}$	3	11	$8\frac{1}{8}$	$11\frac{1}{2}$	$36\frac{1}{8}$	$53\frac{1}{2}$
	51-75 76-100	51-75 76-100	9	$29\frac{3}{4}$	$4\frac{7}{16}$	$27\frac{3}{4}$	$4\frac{7}{8}$	6	$26\frac{1}{8}$	3	11	$8\frac{1}{8}$	$11\frac{1}{2}$	$36\frac{1}{8}$	$53\frac{1}{2}$

Horse Power			Magnetic Switches					
110 V	220 V	550 V	T	U	V	W	X	Holes
1-15	1-15 16-25	1-15 16-25 26-50	6	17	$4\frac{1}{2}$	$15\frac{7}{8}$	6	$\frac{9}{32}$
16-25	26-50 51-75	51-75 76-100	7	18	$5\frac{1}{2}$	$16\frac{3}{8}$	7	$\frac{13}{32}$
26-50	76-100		7	20	5		8	$\frac{13}{32}$

H. P. 110 V 220 V 550 V	Ext. Resis. Req'd.	P	Q
1-15	1	See Outline	
16-25	1	$15\frac{1}{2}$	$17\frac{3}{4}$
26-50	1	17	$19\frac{1}{4}$
51-75	5	$21\frac{1}{2}$	$23\frac{3}{4}$
76-100	7	$21\frac{1}{2}$	$23\frac{3}{4}$

ALL DIMENSIONS IN INCHES

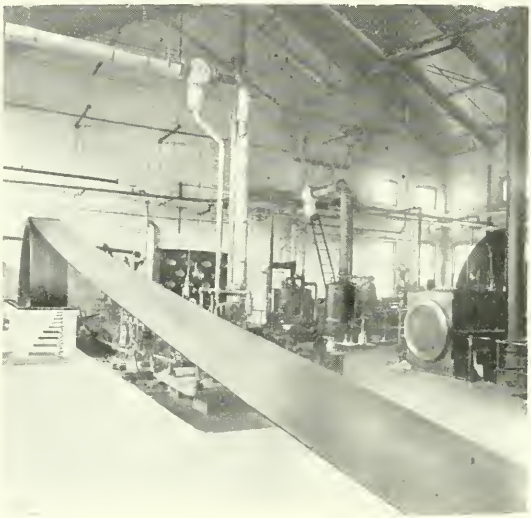
THE B. F. GOODRICH COMPANY

AKRON RUBBER WORKS

AKRON, OHIO - - U. S. A.

RUBBER BELTING FOR POWER TRANSMISSION, BUCKET ELEVATORS AND BELT CONVEYORS; HOSE FOR WATER, STEAM, AIR, GAS, GASOLINE, OIL, CHEMICALS, FIRE PROTECTION, PNEUMATIC TOOLS, AIR DRILLS, FLUE CLEANERS, SAND SUCKERS, DREDGES, SAND BLAST, VACUUM CLEANERS, AIR BRAKES, CAR HEATING, ETC.; GASKETS, VALVES; SHEAVE FILLING FOR WIRE ROPE TRANSMISSION; FRICTION TAPE, ETC.

POWER TRANSMISSION BELTS



MAIN DRIVE BELTS—These require the best quality; and a careful consideration should be given to quality, weight and weave of duck, strength of friction rubber between plies, amount of stretch in service, and the character of cover. We recommend the following grades:

"PINNACLE"—Of the frictioned-surface type, embodying maximum strength, with an extreme quality of rubber between the different plies.

"TITANIC"—Regular covered type - an extra strong, longlasting belt that can be be fully relied upon for hard service.

"PILGRIM"—Regular covered type, built on heavy duck with a substantial grade of friction and cover. A safe, economical belt under normal conditions of service.

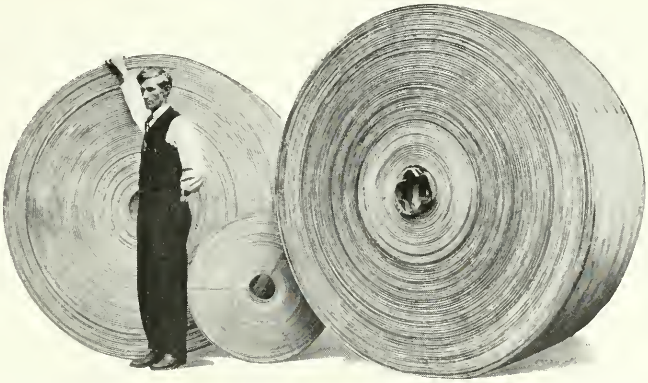
Hard Machine Drives such as paper mill service require the same grades. On small pulleys operating at high speeds such as on wood working machinery, we recommend:

"MARATHON"—a frictioned surface belt of the highest quality, built on specially woven, light, flexible duck.

LIGHT DRIVES such as agricultural service are well met by
"ROB ROY" built on medium weight duck, regular cover
"SIGNAL" built on light weight duck, regular cover.

"GOODRICH AXLE LIGHTING" Belt meets the severest service known, that of electric train lighting from the car axle.

CONVEYOR BELTS



CONVEYING ORE, COAL, ROCK, Etc., calls for special qualities in the belt that have taken years of practical experience to develop. The duck must have maximum strength and extreme flexibility; the friction must not only be strong, but remain so; the cover on carrying side must be able to resist wear to a maximum and also remain pliable and adhere to the fabric; the edges must be properly armored against chafing. We offer the following grades:

"LONGLIFE"—for severe service, and wherever belts ordinarily wear out quickly. Especially recommended where shut downs are costly and where continuous long service is desired.

"MAXECON"—recommended for the more usual light service. While low in price, this is a remarkably reliable and serviceable belt, and for all but the most severe services, it will demonstrate MAXimum ECONomy.

HANDLING GRAIN, PACKAGES, Etc., causes so little abrasion and the conditions are so dry that belts of ordinary construction can be used. We recommend our

"GRAINBELT"—built on medium weight duck, with covers of the usual thickness.

POLISHING BELTS—Somtimes called Emery Belts; built on especially strong fabric with high quality, tough friction.

SHEAVE FILLINGS—Used for lining the grooves of sheaves for rope transmission. We have molds for all shapes and sizes.

ELEVATOR BELTS

MINE AND QUARRY ELEVATORS—A duck of extra strength, quality and weight is required for proper elevator service to resist the tensile strains and the action of the bucket bolts. We use a special, tightly woven duck and recommend the following belts which are built on it:

"AKRON" ELEVATOR BELT—with a high grade friction and cover, and designed for the hardest service.

"STERLING"—a slightly lower grade for general conditions, stitched when handling very wet material.

An extra thickness of rubber cover is supplied on one or both sides, when required.

GRAIN ELEVATORS—Because of the dry conditions and the light material the strains are not so severe and the following belts are recommended:

"PILGRIM"—As described, with heavy duck.
"ROB ROY"—With medium weight duck.

THE GRATON & KNIGHT MFG. CO.

WORCESTER, MASSACHUSETTS, U. S. A.

ATLANTA, GEORGIA
BOSTON, MASSACHUSETTS
CHICAGO, ILLINOIS
MILWAUKEE, WISCONSIN
MINNEAPOLIS, MINNESOTA
NEW YORK, NEW YORK
PHILADELPHIA, PENNSYLVANIA
PORTLAND, OREGON
SAN FRANCISCO, CALIFORNIA
SEATTLE, WASHINGTON
ST. LOUIS, MISSOURI
DALLAS, TEXAS
BRANCH FACTORY AT CLEVELAND, OHIO

OAK LEATHER TANNERS AND BELT MAKERS

Our first tannery, built in 1867, with a capacity of only a few hundred hides annually, has been enlarged until now it has a capacity of over 200,000 hides per annum. We tan under the long time process expressly for belting purposes, and produce leather that is not excelled in strength of fibre or in durability. We describe below a few of our special brands of leather belts. Our complete catalog of leather products free on request.

"SPARTAN"

Is a special belt made from leather tanned particularly to withstand the effects of steam, water, oil, acid or gas fumes, and is especially adapted for hard service.

"Spartan" leather is of special tannage, a process developed by ourselves. It is tough, sinewy, and has our guarantee to withstand exposure to hot or cold water, steam, oil, and heat generated by excessive pulley friction. It is a leather that is not affected by atmospheric changes, therefore does not lengthen and shorten with atmospheric variations.

"SPECIAL PLANER"

Is a special *waterproof* belt made from center stock in single thickness up to 6 inches in width, and constructed of leather weighing 19 to 24 ounces per square foot. It is particularly adapted for heavy work with high speed and small pulleys, such as side and top heads of planers, emery wheel drives, linter drives for cotton-seed oil mills, etc.

"NEPTUNE"

This is the PIONEER *waterproof* leather belting. Ever since its introduction to the trade in 1902, it has been growing in favor, and today is in successful operation in thousands of plants. "Neptune" belting—single, double and three-ply—is made from the very choicest of No. 1 center stock.

"HEART BRAND"

Is heavy single and double leather belting made from the very choicest of first quality oak tanned center stock. Wherever heavy belting is required you may place full dependence upon the "Heart Brand."

"GRA-KNIGHT BRAND"

Is made in both singles and doubles, and is of the same high quality of center stock as the "Heart Brand." It, however, is somewhat lighter in weight, and is, therefore, more generally used in doubles.

"GRA-KNIGHT DYNAMO"

Is made from center stock, same as the "Heart" and "Gra-Knight" brands, only of lighter weight. It is furnished principally in doubles, and is constructed especially for use on high speed machinery, such as motors, fans, blowers, etc. It is of uniform thickness, well balanced, and can be depended upon for long and efficient service.

"EXTRA SHORT LAP"

Is what we term second quality belting, the stock used in its construction being cut from heavy sides. This brand is made in both singles and doubles, but not over 8 inches in width. It is used successfully under conditions where the work does not require strictly first quality belting.

"PRYZOAK BRAND"

Also second quality belting, differs from the "Extra Short Lap" in weight only; it is somewhat lighter. This brand, too, is made in both singles and doubles, but not exceeding 8 inches in width.

THE GRATON & KNIGHT MFG. CO.

"CYLINDER BELT"

The stock used in making the "Cylinder Belt" is cut from shoulders. Although this brand is made in both singles and doubles, it is used principally in doubles. It is a very popular belt for agricultural purposes.

OAK TANNED SOLID ROUND

leather belting is made from stretched No. 1 center stock. This stock is the product of our own tannery and is of superior tensile strength and wearing quality. We make it in all sizes from ⅛ inch to ⅜ inch. inclusive. It is put up on 100, 200, 500, and 1,000 feet spools.

SPARTAN ROUNDED

leather belting is made from the same specially tanned leather as the Spartan flat leather belting. It will withstand the effects of water, staem and gases, and is very pliable. This can be had in sizes from ⅛ inch to ⅜ inch, inclusive. It is put up on 100, 200, 500, and 1,000 feet spools.

TWIST

Twist leather belting, made from oak tanned or Spartan leather, can be had in any diameter from $\frac{1}{16}$ inch upwards. Small sizes are furnished on spools; larger sizes in coils.

PATENT

Patent (built-up) round leather belting, in sizes of from ⅜ inch to ½ inch, can be had in both the Oak Tanned and the Spartan leather.

"ROYAL WORCESTER" LACE LEATHER.

For "Royal Worcester" Lace Leather we make a careful selection of hides, which hides are taken from young animals, and are free from cuts, grubs and other imperfections.

"Royal Worcester" Lacing is a mechanical lace. It is "worked" by special machinery, designed and constructed by our own experts. This special machinery, supplemented by days of hand work by men especially schooled for the purpose, renders the hide very pliable, toughens the fibres and gives to the surface a soft, kid-like finish.

The absence of chemicals in the process of making this lace leather insures long life for the lacing, and adapts it to any climate, because it will not gather moisture and mildew in damp weather, nor does it deteriorate or harden with age.

It is thoroughly stretched during all the processes of manufacturing. hence, does not stretch to bother after it is put into use.

CRESCENT

This is the regular white lace, more commonly called "rawhide," and is the best of its kind that the market affords. It is a chemically tanned lace, and while it is less durable than "Royal Worcester" Lace Leather, it also costs less money.

"V" BELTS

"V" belts for use on fans, motor-cycles and special machinery of various kinds, are made in any desired width or ply, and in either Oak or Spartan Leather. Prices quoted upon receipt of specifications

OTHER GRATON AND KNIGHT PRODUCTS

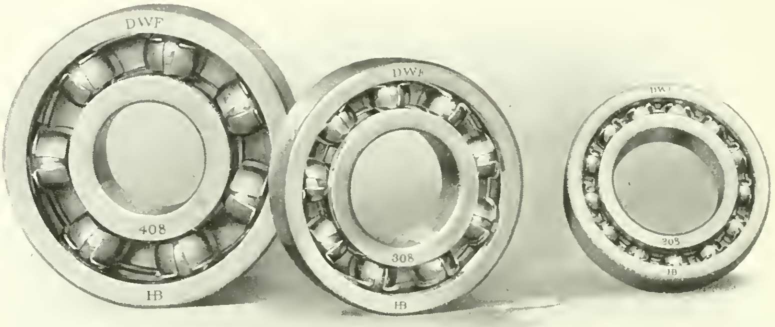
Other Graton and Knight products include the Kelton and Bruce Indian Tanned Lace Leather and Leather Belting, and Tex Tan Belting, also Cup Packings, Washers, Straps, Automobile Leathers, etc.

THE HESS-BRIGHT MFG. CO.

2100 FAIRMOUNT AVE., PHILADELPHIA, PA.

HB MANUFACTURERS AND IMPORTERS OF ANNULAR AND THRUST BALL BEARINGS **DWF**

The advantage of annular ball bearings over the older adjustable type lies in the fact that the original accuracy of the former is permanent during the life of the bearing:—it cannot be impaired and the bearing destroyed by careless use of a wrench.



HESS-BRIGHTS of "heavy," "medium" and "light" series, for same shaft size

The durability of HB-DWF Bearings is further ensured by the use of alloy steels combining file-hardness with extreme toughness; by hardening the balls and races clear through to insure uniform compressibility; by extreme accuracy of size and form, and by polishing balls and race paths to a microscopically smooth surface.

HB-DWF annular bearings are made in three series for equal shaft sizes—viz., heavy, medium and light. The light series may be used where the shaft diameter is out of proportion to the load at that point. Regular sizes run up to 4.33 inches shaft diameter.

HB-DWF thrust bearings are stocked in sizes up to 5.5 inches shaft diameter, and are used for propeller shaft thrust blocks, turbine shafts, gun mounts, and similar service, as well as for light work.

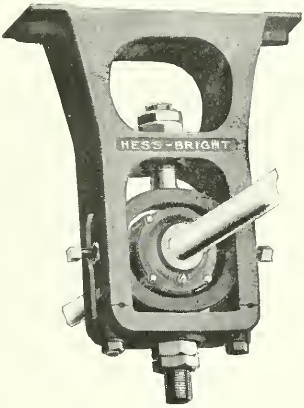
Folder giving complete list of sizes and loads, directions for mounting, etc., sent on request.

HESS-BRIGHT THRUST BEARINGS

HESS-BRIGHT MFG. CO.

DELIVERIES

The combined capacity of the Hess-Bright plant at Philadelphia and of that of the Deutsche Waffen-und-Munitions Fabriken is over 8000 complete bearings per day. This fact guarantees prompt deliveries. Small orders, and even pretty large ones, can usually be filled from stock.



Hess-Bright Ball Bearing Hanger Showing Vertical Adjustment

SPECIAL SIZES AND DESIGNS

Occasionally special conditions require special designs. For these we accept orders covering suitable quantities.

BALL BEARING ENGINEERING

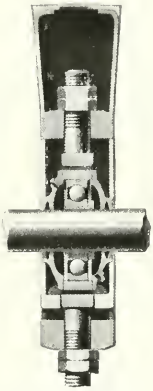
From time to time we issue sheets showing the application of our standard bearings to various classes of machinery. These sheets will be sent to any engineer on request.

APPLICATIONS

Important applications of HB-DWF ball bearings are to automobiles, line shaft hangers, machine tools, woodworking and flour milling machinery, electrical machinery, street railway motors and axles, etc. Where loads are heavy and speeds are high, the friction saved results in important savings of wear and tear and of such repairs as would be necessary with plain bearings.

Hess-Bright Ball Bearing Line Shaft Hangers are designed expressly to meet the requirements of HB ball bearings.

Literature regarding any of the above applications sent on request.

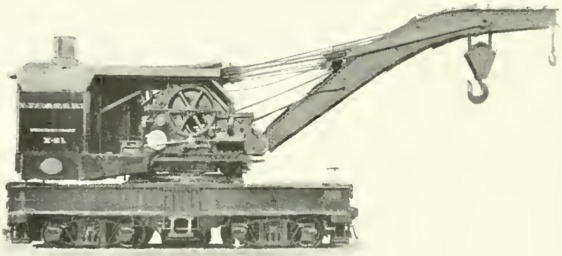


Section of Ceiling Hanger

INDUSTRIAL WORKS

BAY CITY, MICHIGAN

WRECKING CRANES, LOCOMOTIVE CRANES, BUCKET AND MAGNET HANDLING LOCOMOTIVE CRANES, PILLAR CRANES, TRANSFER TABLES, HAND POWER DERRICKS, CLAM SHELL BUCKETS, LIFTING MAGNETS, TRANSFER CRANES, PILE DRIVERS, ETC.



Wrecking Crane, Capacity 120 tons at 17 ft. radius

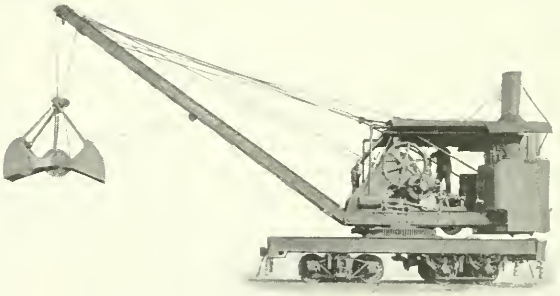
Industrial Works Wrecking cranes are built in six standard sizes with capacities of 40, 50, 60, 75, 100 and 120 tons on the main hoist, and may be self-propelling or non-propelling as desired.

There are three hoisting motions, the main hoist, auxiliary hoist, and jib hoist. These are entirely independent of each other; are provided with independent brakes and operated by independent trains of cut steel gearing so that changes from one motion to the other are made with ease, and all parts are open and accessible.

In none of the three motions is any use made of ratchets for holding suspended loads, either during operation or during transfer from one motion to the other. These functions are performed by powerful brakes and self-locking worm wheels which enable the operator to use the motions with rapidity and safety.

Stability is provided by a system of telescopic outriggers, all of which are self-contained within the car body.

LOCOMOTIVE CRANES



Locomotive Crane for yard and road service

Industrial Works Locomotives Cranes are manufactured in four standard sizes: 5 to 7 tons, 10 to 12 tons, 10 to 17 tons, and 20 to 30 tons capacities. The cut above shows our 20 to 30 ton locomotive cranes, but the same structural and mechanical features are found in all the several sizes noted above. The smaller cranes are mounted on either four or eight wheel cars.

INDUSTRIAL WORKS PRODUCTS

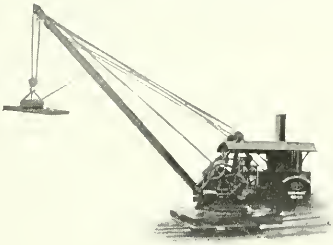
These cranes are provided with double reversing engines and vertical boiler of ample capacity. The motions of hoisting, slewing and propelling are operated through separate friction clutches and trains of cut steel spur and bevel gearing. The radius varying motion is controlled through a steel jaw clutch and an improved Hindley worm.

The hoisting motion is provided with a powerful quick acting foot brake capable of sustaining the full rated load. The slewing motion is provided with an efficient friction brake which holds the revolving part of the crane in any position relative to the car. When loads are carried suspended and the crane is operated on uneven tracks or curves the slewing of the crane is under control of the operator and cannot suddenly rotate with possibly disastrous results.

The propelling mechanism is also provided with a quick acting friction brake of sufficient capacity to hold the crane in a stationary position when working on uneven tracks or grades. The eight wheel M. C. B. type cars have in addition hand brakes, air brakes and other Interstate Commerce Commission requirements.

When desired, the cranes may be equipped with an auxiliary drum and connections, for operating Grab Buckets, and complete equipment for operating Lifting Magnets.

Detailed specifications and full particulars furnished on application.



MAGNET CRANES

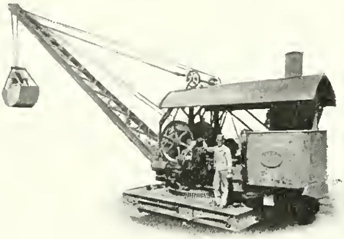
Any of our cranes may be equipped for handling a lifting magnet of any approved type.

For safe, rapid, convenient, and economical handling of metals the Lifting Magnet operated by a Locomotive Crane is unsurpassed.

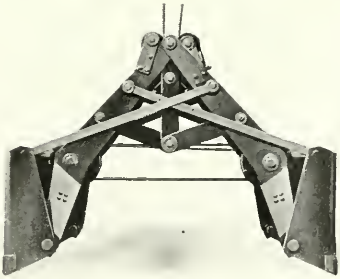
BUCKET HANDLING CRANES

When desired, our locomotive cranes may be equipped with an auxiliary drum and connections for operating a grab bucket. Either the Clam Shell or the Orange Peel type bucket may be used.

The locomotive crane and grab bucket have been proven by Railroads, Contractors, Manufacturers and others to be quick and economical for handling ore, coal, cinders, gravel, sand and similar materials.



CLAM SHELL BUCKETS



The Clam Shell Bucket here illustrated has been developed along the lines of the most powerful ore handling buckets in use. The operating ropes and sheaves are kept very high up out of the way of the material when open, and its greatest closing power is exerted at the instant of closing, thus enabling it to handle successfully materials quite impossible for the ordinary bucket.

See also next page

INDUSTRIAL WORKS PRODUCTS

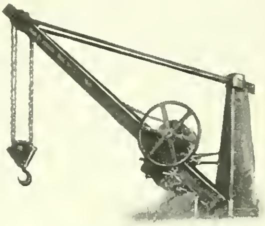
Continued from preceding page

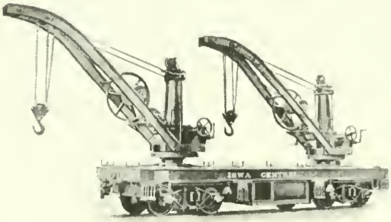
TRANSFER CRANES

Transfer Cranes from ten to thirty tons capacity are especially in demand for transferring freight from one car to another or an adjacent track as indicated by the arrangement shown in the accompanying illustration. The savings effected by their use are sufficiently great to justify their installation at even comparatively small sidings. These cranes are designed for operation by hand power or an electric motor.

PILLAR CRANES

Pillar Cranes similar to accompanying illustration are used in much the same service as the Transfer Crane and are located at freight stations to transfer heavy freight from cars to teaming trucks or vice-versa, also from car to car. These cranes range in capacities from two to thirty tons, and may be operated by hand power or electric motor.



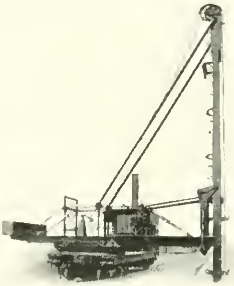


HAND DERRICKS

While Steam Cranes are now used almost universally by all railroads, the Hand Power Derrick is sometimes installed at less important points or on smaller lines of road where the Rolling Stock or wrecking service is not heavy. These cranes are designed to handle fifteen tons and may be built with a single crane on the car, or double as shown in illustration.

TRANSFER TABLES

Where a system of parallel shop tracks is installed the Transfer Table is used to transfer locomotives and cars from one track or shop to another, and from the shop tracks to the main line. They are usually operated by Electric power.



PILE DRIVERS

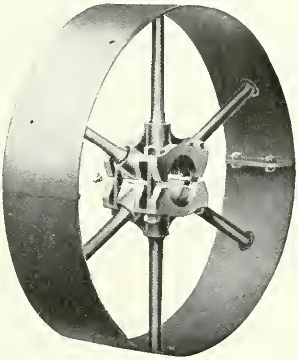
Pile Drivers for Railroad Service have been developed by the Industrial Works to a very high degree of efficiency. The pile driving machinery is mounted on either a wood or steel car body equipped with M. C. B. air brake equipment, and all slewing, raising and lowering of leaders, etc., is done by power.

KEYSTONE PULLEY COMPANY

ONEIDA, NEW YORK

MANUFACTURERS OF

KEYSTONE STEEL SPLIT PULLEYS

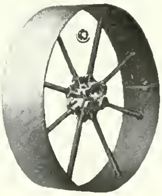


SIX ARM CONSTRUCTION

Keystone Steel Pulleys approach closely to perfection in the manufacture of metal pulleys. Users will find they give satisfaction against breakdowns and imperfect drives.

Keystone Steel Pulleys are used by many of the largest firms throughout the United States on account of their strength, simplicity, good finish and manufacturing results.

The rim of each half is made of one piece of solid steel and presents an unbroken belt surface.



EIGHT ARM CONSTRUCTION

The arms are round, solid steel forged, electrically welded to rim, are forced home by hydraulic pressure and become an integral part of the hub.

The hubs are bored insuring true running and accurate fit on bushings.

All bolts and nuts are easily accessible on all sizes.

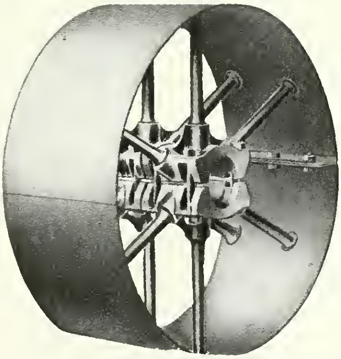
The best pulley on the market for double belt service.

TEN ARM CONSTRUCTION

Keystone pulleys are made with six, eight, ten, twelve, sixteen and twenty arms.

Range of Sizes.

Diam.	-	-	-	12″ to 60″
Face	-	-	-	3″ to 16″
Bore	-	-	-	$\frac{3}{4}$″ to 4 7-16″



TWELVE ARM CONSTRUCTION

SIXTEEN ARM CONSTRUCTION

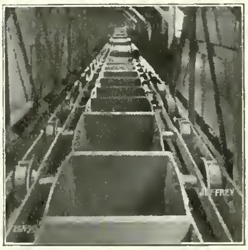
SEND FOR CATALOGUE.

THE JEFFREY MANUFACTURING CO.

COLUMBUS, OHIO

CHICAGO
ST. LOUIS
DENVER
MONTREAL
PITTSBURG
ATLANTA, GA.
CHARLESTON, W. VA.
BOSTON
NEW YORK
BIRMINGHAM

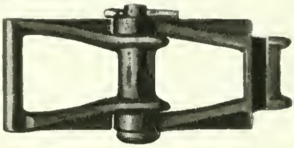
ELEVATING, CONVEYING, AND POWER TRANSMISSION MACHINERY



Jeffrey Pivoted Overlapping Bucket, Conveyor Elevator

JEFFREY PIVOTED OVERLAPPING BUCKET CONVEYOR ELEVATOR

for delivering coal to storage bunkers. The return strand carries ashes from the ash hopper.

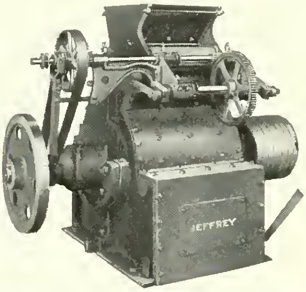


JEFFREY CHAINS

are interchangeable with all Standard Chains.

We carry a large stock for prompt delivery.

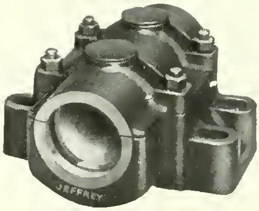
Special Chains made to order.



JEFFREY SWING HAMMER PULVERIZER

View shows Jeffrey Swing Hammer Pulverizer, size 36″ x 24″; capacity 12 tons limestone per hour, 75 per cent. will pass 80 mesh.

Write for Calatog 31

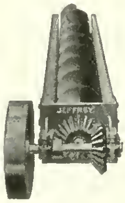


PILLOW BLOCKS

Journal Boxes, Pulleys, Friction Clutches, Rope Drives, etc.

BUCKET ELEVATORS

for handling coal, stone, ore etc., made in styles and sizes to suit conditions.



Spiral Conveyers for handling grain, coal, ore, sand, seed, etc., are strong and reliable.

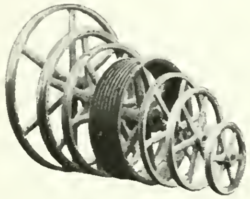
JEFFREY SCREENS

for treating coal, stone, cement, clay, etc.

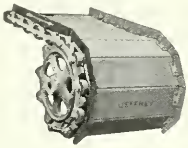
Let us know the character of the material to be treated, and we will specify the best style screen for your work. Jeffrey screen Book 69 mailed upon request.

THE JEFFREY MANUFACTURING CO.

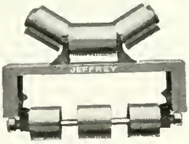
Jeffrey trade catalogs covering the manufacture and application of a complete line of elevating, conveying and power transmitting appliances are briefly summarized below.



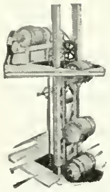
Jeffrey Sheaves, V and U grooved, accurately turned, bored and balanced. Stock sizes 12″ to 108″ diameter, grooved 1″ to 12″. Special sizes made to order.



Apron Conveyers made in sizes and weights to meet all requirements. Built with wood or steel slates.



Rubber Belt Conveyers for handling various materials; easy to install, require less power and have greater capacity than any other makes.



Elevators designed and built to suit all requirements for handling barrels, boxes, crates, packages, etc.

Bearings
Belting—for conveyor duty
Belt Tighteners
Buckets, Elevator
Buckets, Grab and Clam Shell
Cable, Chain
Cable, Wire
Cages, Mine
Car Hauls
Cars
Chains, in cast steel, forged steel, iron, malleable iron, for gritty work, light work, heavy work, self oiling, hand oiling, detachable or rivetted and interchangeable with other makes
Chutes
Clamps
Clutches
Coal and Coke Handling Machinery
Coal Crushers
Coal Cutting Machines, Coal Drills
Coal Jackets
Coal Tipples
Conveyors, for logs, mill refuse, lumber, coal, ashes, ore, ice, freight, merchandise, grain, cotton and hot material, etc., etc.
Conveying Belts
Couplings, Clutch Couplings, Collars, Friction Clutches
Crab Hoists
Drills, Electric, Rotary and Hand Power
Electric
Locomotives
Elevators
Fans, Mine
Gantry Cranes
Gears
Generators
Hangers
Floor Stands
Hoists, Crabs, Electric Drum Hoists, Gantry Cranes
Larries, Coke
Locomotives, Electric
Picking Tables
Power Houses
Pulleys, moulded in metal or wood with single and double arms
Rope—Transmission, Hoisting, Haulage
Screens for any material, Rotary or Vibrating
Screw Conveyors and cast iron end journal boxes for same
Shafting
Sheaves
Spiral Coveyors
Sprocket Wheels
Tension Carriages
Tipples, Coal
Washeries Coal
Weigh Hoppers
Wire Cloth

LAMSON CONSOLIDATED STORE SERVICE COMPANY

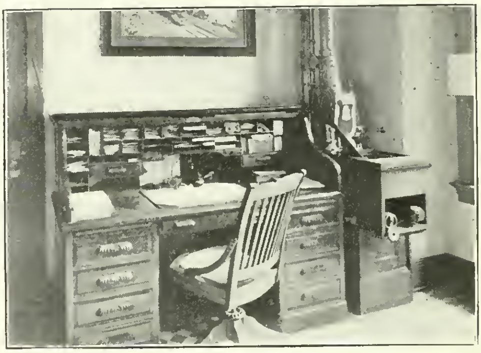
BOSTON, MASS., U. S. A.

PNEUMATIC TUBES—CASH, PARCEL, MESSAGE, AND MAIL CARRIERS; AUTOMATIC, SWEEP-OFF, PICKUP AND SELECTIVE CARRIERS; BELT CONVEYORS, SMALL LIFTS, ELEVATORS, ETC.

LAMSON PNEUMATIC TUBES

Designed and installed for all possible business or store service requirements—sizes from 2¼ to 8 inch. Latest Power-Saving Improvements.

Over 50,000 Stations in use.

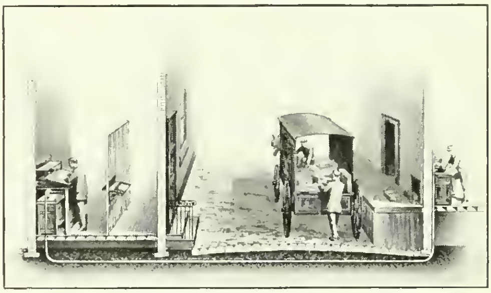


Desk Station 4″ Mail Tubes in Private Office

LAMSON FOOT-POWER TUBES

No power plant required, operated by foot pressure. Efficient for lines up to 200 feet in length. Speaking tube attachments at small additional cost.

Sizes 2¼ and 3 inch O. D.



Carrying Documents Between Buildings

LAMSON SELECTIVE CARRIERS

Entirely automatic—pick up a load at any point and deliver it at any desired station.

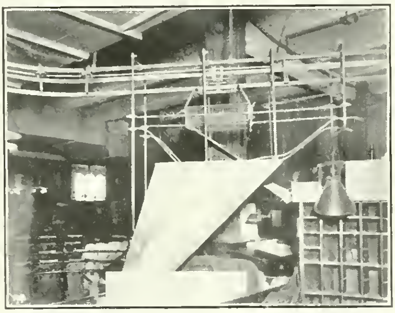
Made in any size to meet requirements—from carrying single sheets of paper to heavy bags of mail.

Automatic Mail Bag Carriers

LAMSON CONSOLIDATED STORE SERVICE COMPANY

LAMSON AUTOMATIC DELIVERY BASKET CARRIERS

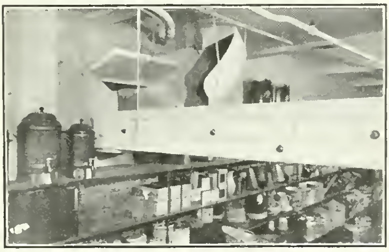
Sweeps off Mail Documents or parcels from shelves and dumps them at required Station—Made in standard sizes or to specifications.



Lamson Sweep-off and Dump Carriers for Post Office Work

LAMSON BELT CONVEYORS

All sizes for all conditions of Mail, Merchandise or Parcel Carrying. Particular attention to Belt Conveyor Systems for Assembling and Delivery, Car and Transfer Parcels in Department Stores.



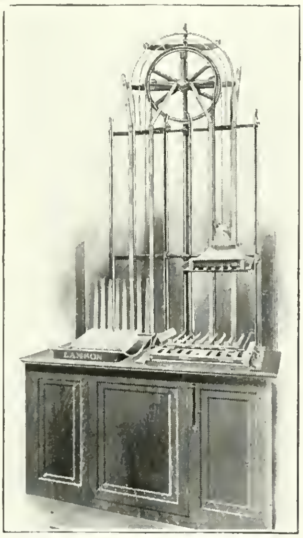
Store Service Belt Conveyor and Chute Showing Self-closing Fire Door

LAMSON SPECIAL CONVEYORS

Made to meet any demand for assembly and distribution of Mail or Merchandise within or between buildings.

Plans and Estimates Free.

Agencies in all Principal Cities.



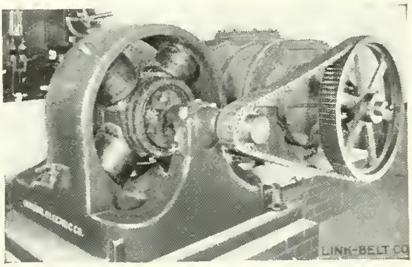
Will pick up at any station and deliver at any other station

LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

NEW YORK, 299 Broadway
PITTSBURGH, 1501-3 Park Bldg.
ST. LOUIS, Central Nat'l Bank Bldg.
BUFFALO, 601 Ellicott Sq.
BOSTON, 131 State St.
SEATTLE, E. G. Brabrook
DENVER, Lindrooth, Shubart & Co.
NEW ORLEANS, Wilmot Mchy. Co.
SAN FRANCISCO, Eby Machinery Co.

ELEVATING & CONVEYING MACHINERY
POWER-TRANSMISSION CHAINS



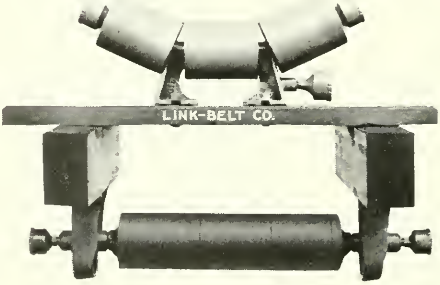
45-H.P. "Maximum" Silent Chain Drive Operating Blower

"Maximum" Silent Chain for High-Speed Power Transmission.

The chain is made of stamped links of special form, hardened-steel pins, removable bushings and washers. It is made in eight pitches, and in many widths in each pitch.

PECK PIVOTED OVERLAPPING BUCKET CARRIER FOR BOILER HOUSES, CEMENT MILLS, ETC.

Horizontal Run of Peck Carrier in Cement Mill



BELT CONVEYORS

LINK-BELT COMPANY

PHILADELPHIA CHICAGO INDIANAPOLIS

OUR MANUFACTURES INCLUDE

Complete Coal Tipple Equipments
Coal Washeries

Slack Conveyors
Car-Hauls
Coal Pockets
Coal Crushers
Picking Tables
Screens, Chutes
Hoppers
Screw Conveyors
Crushed Stone, Sand and Gravel Handling Plants
Elevators, Screens and Dredges for Placer Mining

Locomotive Coaling Stations

Locomotive Cranes
Telphers
20th Century Asphalt Paving Machine
Industrial Railways

Power House Fueling Equipments
Roll Crushers of all types for Coal, Coke, etc.

ELEVATORS & CONVEYORS FOR EVERY PURPOSE

Power-Transmission Machinery

Original "Ewart" Detachable Link-Belt, Chains — all types Attachments, Hangers, Pillow-Blocks, Friction Clutches, Flint-Rim Sprocket Wheels, etc.

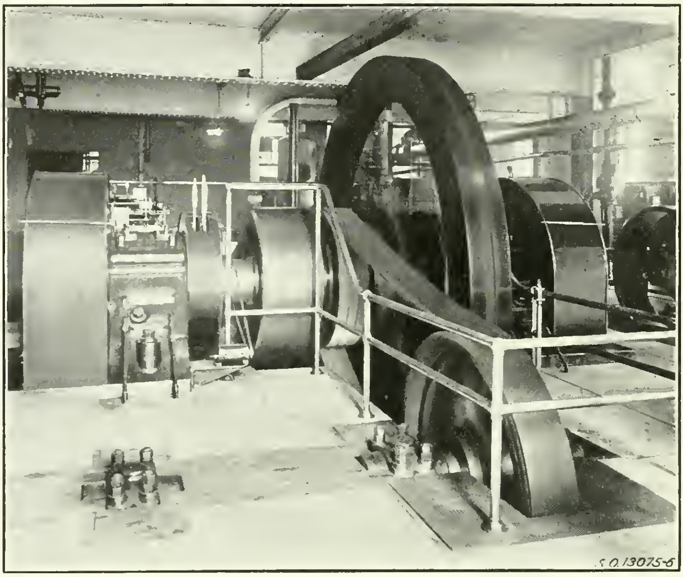
The following catalogs sent on request

No. 90—400 page General Price-List
No. 78—Retail Coal Pockets
No. 81—Peck Carrier
No. 83—Conveyors for Freight and Packages
No. 95—Conveying Machinery for Coal Mines
No. 96—Conveying Machinery for Sugar Estates
No. 102—Maximum Silent Chain
No. 121—Friction Clutches

MORSE CHAIN COMPANY

ITHACA, NEW YORK

MORSE SILENT RUNNING HIGH-SPEED CHAINS AND SPROCKETS



The Morse Silent-Running Power Chain is essentially a steel belt made of flat links so shaped as to form teeth on one side of the chain, which engage with teeth cut in the sprocket wheel on which it runs.

It is used in place of belting or gears to transmit power for any purpose and is made in sizes varying from ¼ H.P. at 3000 R. P. M. to 3000 H.P. at slow rotative speeds, an aggregate of over 500,000 H.P. being now in successful daily operation.

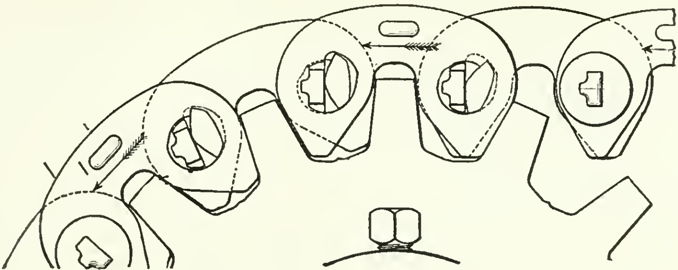
By its use power may be transmitted with a positive speed ratio on short centers, quietly and with an efficiency of nearly 99 per cent.

This high efficiency is due to the use of the Morse Frictionless Rocker Joint, which consists of two pins of hardened tool steel, each forming half of the joint and so shaped and held that as the chain bends, the rounded edge on one pin rocks upon the flat side of the other, thus substituting a rolling motion for the rubbing friction found in all other chain joints. When the chain is straight the flat seat pin bears against one of the flat faces of the rocker pin, so that it is only when the chain bends that the load comes upon the rounded edge of the rocker. This prevents undue vibration in the strands of the chain between the sprockets and reduces wear of the rolling base.

The chain should be lubricated with a heavy paste grease containing no solid matter.

The chains are made in a variety of widths to suit the power transmitted and in ten pitches, the number of revolutions of the smaller sprocket determining the pitch to be used, as shown by the following table:

(See next page)



Morse Chain, Type 25, Showing Joint Action.

MORSE CHAIN AND SPROCKET DATA

PITCH		$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{9}{10}$	$1\frac{2}{10}$	$1\frac{1}{2}$	2	3
Min. No. of Teeth	Small Sprocket Driver	13	13	13	15	15	17	17	17
	Small Sprocket Driven	17	17	21	25	29	29	31	35
Desirable number of teeth in small sprockets		15–17	17–21	17–21	17–23	17–23	17–27	17–31	19–31
Maximum number of teeth in large sprockets (See Note 3.)		99	109	115	125	129	129	129	131
Desirable number of teeth in large sprockets		55–75	55–75	55–85	55–95	55–105	55–115	55–115	55–115
To find pitch diameter of wheel multiply No. of Teeth by		.159	.199	.239	.2865	.382	.477	.636	955
Addendum. For outside diameter of sprockets 20 to 130 T. (See Note 1.)		.05	.06	.075	.09	.12	.15	.20	.30
Maximum R. P. M.		2400	1800	1200	1100	800	600	400	250
Tension per inch width chain	Small Sprocket Driver	80	100	120	150	200	270	450	750
	Small Sprocket Driven	65	80	95	120	160	210	350	600
Radial clearance beyond tooth required for chain		0.50	0.62	0.75	0.90	1.2	1.5	2.0	3.0
Approximate weight of chain per inch wide, 1 foot long		1.00	1.20	1.50	1.80	2.50	3.00	4.00	6.00
C Constants for Steel Pinions		0.0045	0.0063	0.009	0.012	.023	.035	.058	145
C Constants for Cast Iron Sprockets		0.16	0.25	0.35	0.45	0.7	1.	2.	4.

Note 1. Number of teeth = T.
Exact Outside Dia. = D.
When T has less than 20 teeth, D = Pitch Dia.
When T has more than 20 teeth, D = Pitch Dia. + 2xAddendum.

Note 2. Use sprockets having an odd number of teeth whenever possible.

Note 3. When specially authorized, a larger number of teeth than shown may be cut in large sprocket.

Note 4. Thickness of sprocket rim, including teeth, should be at least 1.2 times the chain pitch.

Note 5. The number of grooves in the sprocket, their width and distance apart varies according to pitch and width of chain. In every case leave the designing and turning of these grooves to the Morse Chain Company.

Note 6. The width of the sprocket should be $\frac{1}{8}$ to $\frac{1}{4}$ inch greater on small drives, and $\frac{1}{4}$ to $\frac{1}{2}$ inch greater on large drives than nominal width of the chain.

Note 7. The chain should have an even number of links and the wheels an odd number of teeth.

Note 8. Horizontal drives preferred; tight chain on top desirable for short drives without center adjustment.

Note 9. Adjustable wheel centers desirable for horizontal drives and necessary for vertical drives.

Note 10. Avoid vertical drives.

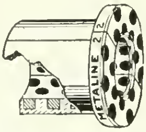
Note 11. Allow a side clearance for chain (parallel to axis of sprockets and measured from nominal width of chain) equal to the pitch.

Note 12. Desirable linear velocity for commercial service 1200 to 1600 feet per minute.

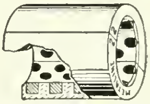
NORTH AMERICAN METALINE CO.

WEST AVE. NEAR BORDEN, LONG ISLAND CITY, N. Y.

METALINED OR OILLESS BEARINGS AND BUSHINGS



Flanged Bushing for loose pulleys or for boxes having an end or collar bearing



Plain Bushing for boxes or pulley block sheaves where there is no end bearing

Metaline is composed of metallic oxides and other substances reduced to an impalpable powder and then solidified in hardened steel moulds under great pressure into short length plugs $\frac{3}{16}$ in., $\frac{1}{4}$ in. and $\frac{5}{16}$ in. in diameter.

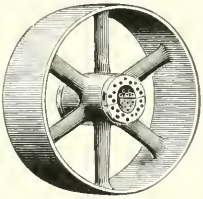
These plugs are inserted into holes drilled in divided bushings of gun metal bronze, phosphor bronze, or composition metal of good quality.

The two halves of the bushing having been soldered together and then machined all over to specified finished dimensions, are separated and holes drilled into the bearing surface—not all the way through the wall of the bushing—into which the metaline plugs are tightly fitted and then filed flush with the bearing surface, care being taken to see that the spacing of the plugs is such that they will overlap or break joints, particularly along the line of motion.

Bearings fitted with plugs of Metaline as described above are self-lubricating, being positively oilless; indeed no oil or other lubricant should be used.

It has been proved that they last for many years, and, if the Metaline plugs are renewed before over-much wear of the bearing surface has taken place, the life of the bushing or bearing will be very greatly prolonged.

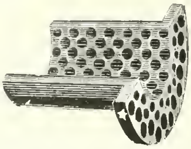
Cleanliness is a very desirable feature, which with the elimination of the danger of fire, a risk attending the use of fluid or semi-fluid lubricants in the other types of bearings, should particularly commend the use of Metaline.



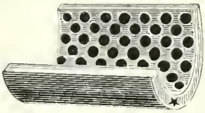
Loose pulley after being fitted with a set of two metalined flanged bushings

Sheave fitted with plain or unflanged metalined bushing

It is conceded by the manufacturers that metalined bearings are not suitable for some lines of service; but it is claimed that these bearings give unusual satisfaction for tackle blocks, wire rope and tramway sheaves, loose pulleys, friction clutch pulleys, idler and mule pulleys, elevator pulleys and other places where the bearing revolves around the shaft; line and counter shaft boxes, floor stand boxes, ventilating fans, small motor bearings, etc.



One-half flanged bushing



One-half plain bushing

ONEIDA STEEL PULLEY COMPANY

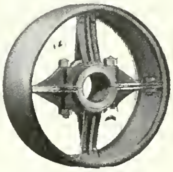
ONEIDA, NEW YORK

MANUFACTURERS OF HIGH GRADE STEEL PULLEYS

The ONEIDA has the best possible belt adhesion since the oval crown face fits the belt perfectly.

Being held to the shaft by compression the bolts may be drawn extremely tight making it practically a positive drive.

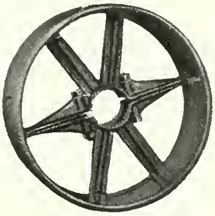
Owing to the blade like arms the ONEIDA has slight windage.



11 x 3 x 3½

This pulley weighs but ¼ to ⅓ as much as a cast iron pulley and thereby saves from ⅜ to ⅔ of the actual H. P. required to revolve a cast iron pulley.

The particular advantage of the Oneida is that it is made in the greatest range of sizes of any steel pulley in the world, thus making it possible to equip any mill complete with one make of pulley. They may be made to fit any standard size shaft by means of a system of interchangeable bushing.

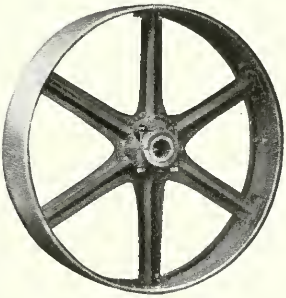


16 x 4 x 3½

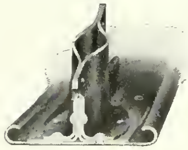
Range of sizes

Diameter - - - -	6″ to 126″
Face - - - -	2″ to 40″
Bore - - - -	¾″ to 8½″

Is made in split form and is thereby easily erected on shaft and does not necessitate the removal of other pulleys and hangers to be placed in position.



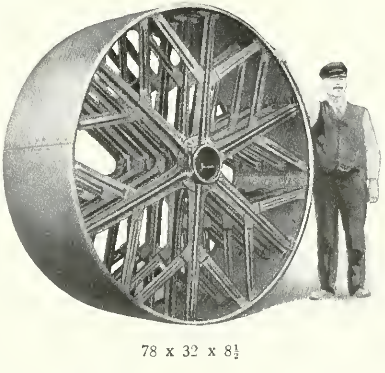
34 x 6 x 3½



This illustration shows the fishplate reinforcement of rim and style of riveting to the arms. Note how the parts are made male and female. Impossible to bring to bear a shearing strain on the rivets that would cut them.

We also manufacture belt and conveyor pulleys, drums, elevator, head, tail and tripper pulleys, flange and special railroad pulleys.

Send for our large and complete catalogue.

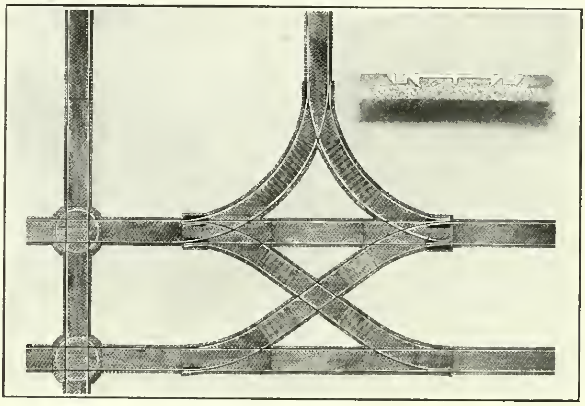


78 x 32 x 8½

ORENSTEIN-ARTHUR KOPPEL CO.

PITTSBURG, PA.

INDUSTRIAL AND PORTABLE RAILWAY TRACK, SWITCHES, ETC.
STANDARD AND SPECIAL CARS FOR ALL PURPOSES



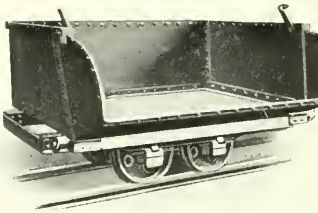
Cast Plate Track

This track is made for shop or boiler rooms or any other place where it is desired to maintain an even surface. The rails are cast solid with the plates, the space between the rails being level, and the surface of the plate checkered, thereby affording an excellent foot hold for the workman. The plates are so made that the sections interlock and maintain permanently their alignment and level. The remainder of the floor area may be covered with our cast iron floor plates, making a floor unequalled in appearance and durability.

This illustration shows a car for the conveying of coal to boiler rooms. It may be constructed with two side doors or with end doors when desired. These cars can be supplied with swivelling wheel base.

The height of the car is such as to make shoveling very easy for the stoker.

In connection with our boiler room track shown above, these cars give an economical and cleanly method of bringing coal from stock piles to fire doors.



Fuel Car

Cradle Dump Type V-Shaped Car

The V-shaped double side dump car is the most desirable for automatic unloading, and for the transportation of various loose materials, such as crushed stone, concrete, sand, excavated soil, coal, ashes, slack, scrap, farm products, etc. These materials can be readily dumped to either side from these cars.

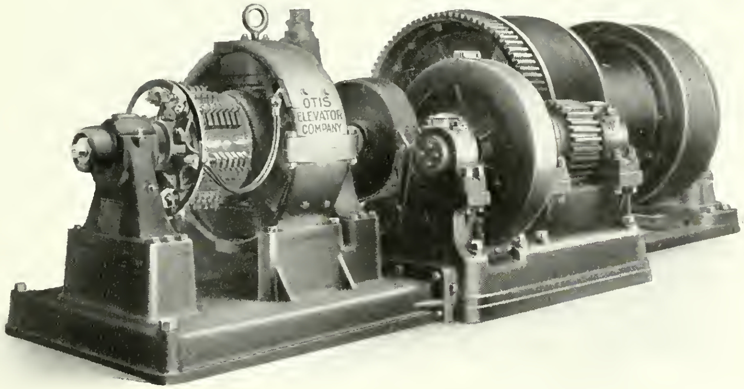
These cars are built for capacities of from two-thirds to eighteen cubic yards and are of all steel construction.

OTIS ELEVATOR COMPANY

NEW YORK CHICAGO SAN FRANCISCO

OFFICES IN ALL PRINCIPAL CITIES

ELECTRIC AND STEAM HOISTS



Automatic Electric Skip Hoist

Our Automatic, Electric Skip Hoists, both alternating and direct current, are especially designed for use in

Blast Furnaces,
Limestone Plants,
Incline Railways,
Stone Quarries

and all other places where Automatic Control is demanded under severe and unusual conditions.

Let our Engineers co-operate with you in solving your hoisting problems.

Correspondence Solicited.

PHILADELPHIA GEAR WORKS

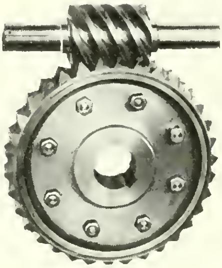
PHILADELPHIA, PENNSYLVANIA

MANUFACTURERS OF BEVEL GEARS WITH PLANED TEETH; GEAR WHEELS AND GEAR CUTTING OF EVERY DESCRIPTION; RAWHIDE AND FIBRE GEARS.

PRODUCT AND QUALITY

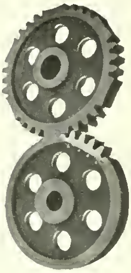
Our works are equipped for manufacturing high grade gears of any size or description. Our standard gears are very fully listed in our catalogue and many special gears are illustrated also. Our long experience in cutting gears enables us to execute work promptly and efficiently. Iron, Steel, Brass, Rawhide and Fibre gears supplied.

SAMPLES OF OUR WORK



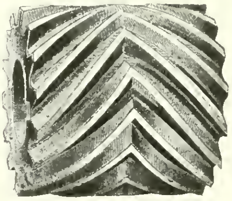
WORMS AND WORM GEARS

Any material or combination, most any size



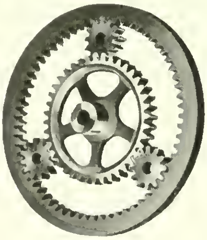
INTERMITTENT GEARS

We make to order Intermittent Gears of every description, brass, iron or steel; spur, bevel, or internal.



HELICAL OR HERRING-BONE GEARS

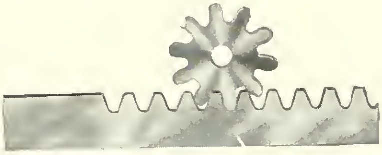
Single or double, right or left hand, of iron or steel, made to order.



INTERNAL GEARS

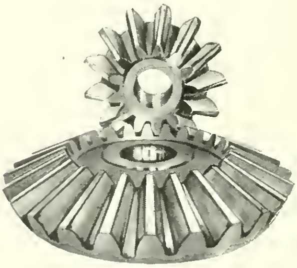
We make or cut them of every description, any pitch from 3 to 48.

Any diameter to 36 inches. Any face to 4 inches. Iron, brass or steel.



RACKS OF ANY SIZE

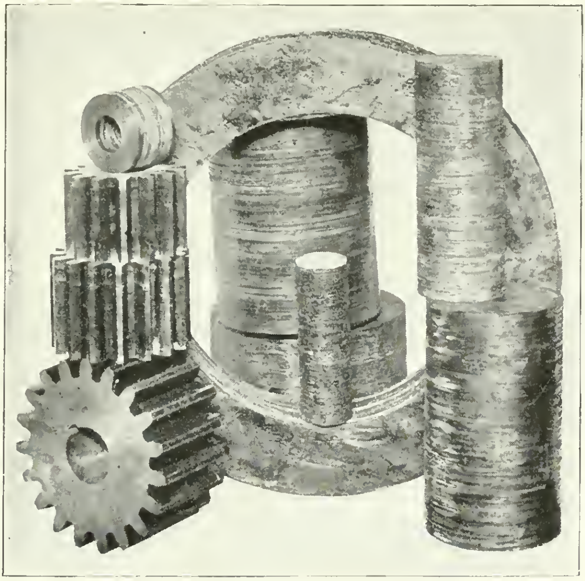
Racks of any size furnished to order, any pitch from 64 to 3. We make them of cast iron or brass any length to 36 inches. Of steel, any length to 20 feet.



BEVEL AND MITER GEARS PLANED TEETH

MADE TO ORDER

RAWHIDE AND FIBRE GEARS MADE TO ORDER



"MATCHLESS" RAW-HIDE

In our Raw Hide Gears you get the very best of material obtainable.

This Raw Hide comes from the East, and far outranks any other in elasticity, resilience, and is a finer grain of tougher quality, owing to the climatic conditions, vegetation and care of the stock.

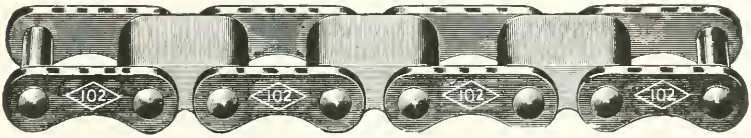
In the manufacture there are kinks that the best of mechanics can learn through experience only, and this work is done by a special corps of men.

We use a special moisture proof compound under enormous pressure for a specified length of time, which makes each piece the duplicate of its predecessor.

The Roughing, Turning, Riveting and Cutting are all done by special machinery for this special purpose, thereby producing a gear far superior to one made by ordinary methods.

We carry Raw Hide blanks from 2 inches to 12 inches in diameter, 12 inches long, and are prepared to make extraordinary quick deliveries.

DIAMOND AUTOMOBILE CHAIN



Straw tempered B blocks — top polished, blue solid B sides, — Blocks made from open hearth steel.

All Sizes "Diamond" roller chain in stock, Chrome Nickel and high Carbon Steel.

FOR YOUR AUTOMOBILE

Sprockets for any pitch, for any chain, made of bronze or of steel forgings, from the old sample. Always send at least a foot of the chain. Very prompt delivery for urgent cases.

POOLE ENGINEERING & MACHINE COMPANY

BALTIMORE, MD.

MANUFACTURERS OF GEARING, SHAFTING, PULLEYS, HANGERS AND BUILDERS OF HEAVY MACHINERY

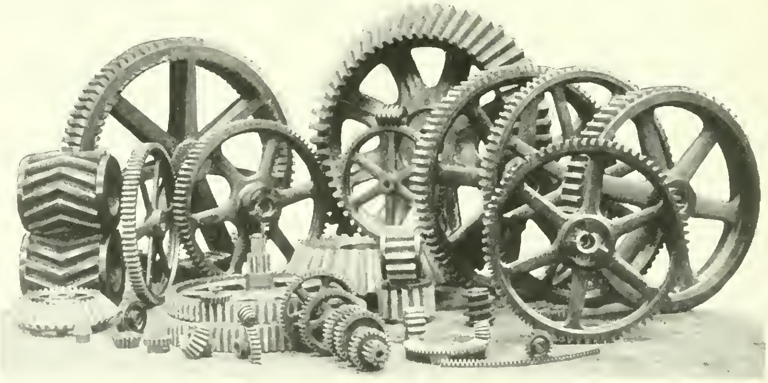
Machine Moulded Gears

In the regular course of our long established business we have accumulated a large number of forms for making our well known machine moulded gears. Our catalog contains a carefully compiled list of those forms now on hand and we can make promptly by our system any size or shape not now on hand.

The reputation of our machine-moulded gears is now too thoroughly established to make it necessary to enlarge on their advantages except to mention that we use a grade of iron especially suited to the purpose of highest Tensile Strength.

Cut Gears

Our facilities for spacing, cutting and planing gears of all kinds cannot be surpassed. Gears from the smallest up to fifty feet diameter have been manufactured by our works.



Shafting, Pulleys and Hangers

The proportions and design of our Pulleys and Hangers are equal to the best. The largest and heaviest work can be handled at our works and we quote upon complete transmission installation or upon any part of the equipment.

Couplings, Clutches and Sheaves

Double Cone Couplings, and Plate Couplings are of our standard design. Our Friction Clutch is compact and durable. It is of the enclosed type with all parts interchangeable. We make rope sheaves, fly wheels and pulleys from eighteen inches up to fifty feet diameter. Also plain and pitch chain sheaves in a great variety of sizes. The finish and proportion of these wheels and of our rope transmission wheels are unexcelled.

THE ROSSENDALE-REDDAWAY BELTING AND HOSE COMPANY

NEWARK, N. J., U. S. A.

"CAMEL HAIR" BELTING, CANVAS STITCHED BELTING, SOLID COTTON BELTING, ARABIAN "ASBESTOS BRAKE LINING"

"CAMEL" BRAND "CAMEL HAIR" BELTING

This belt is remarkable for its great strength (almost twice that of the leather belting), long life, small slippage, minimum stretching, straight true running, and for the fact that it is less affected by dampness or acid fumes than any other kind of belting. This belting is also sold under a guarantee that it will give longer, better service than any other style of belting running under the same conditions. Made in four thicknesses as follows:

SINGLE "CAMEL" which corresponds to single leather or to 4-ply canvas and rubber.

MEDIUM "CAMEL" which corresponds to heavy single leather or to 5-ply canvas and rubber.

DOUBLE "CAMEL" which corresponds to double, and heavy double leather or to 6- to 8-ply rubber and canvas.

Extra heavy "Camel" to correspond to triple leather and all extra heavy types of belting.

STITCHED CANVAS BELTING "SPHINX BRAND"

Thoroughly equal to the best on the market in this type of belts, and affords economy if substituted as follows:

8-ply in place of double leather or 5 and 6-ply rubber.
6-ply in place of light double leather or 5-ply rubber.
4-ply in place of single leather or 3-ply rubber.
10-ply where extraordinary strength is required.

Made in all weights.

"BLACK-BIRD" WOVEN COTTON BELTING

FOR TRANSMISSION AND CONVEYOR WORK

An improved woven belt manufactured under high tension from the finest quality of long-staple cotton.

Impregnated with a special composition which protects the fibre, keeps the belt pliable, and prevents it from becoming hard and dry.

Will run well in steamy or wet places and on drives exposed to the weather.

ARABIAN "ASBESTOS BRAKE LINING"

Especially suitable for automobile brakes. Made in all widths from one to four inches. Standard thicknesses $\frac{3}{16}''$ and $\frac{1}{4}''$.

H. J. REEDY COMPANY

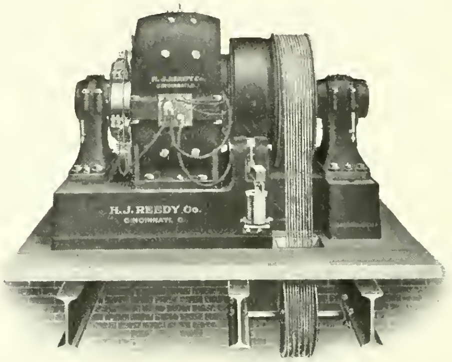
CINCINNATI NEW YORK CHICAGO

MANUFACTURERS OF ALL TYPES OF PASSENGER AND FREIGHT ELEVATORS

ELECTRIC ELEVATORS

We build, among others, the following types of electric elevators, equipped with every modern safety and controlling device consistent with perfect safety, simplicity and durability.

Traction Elevators, 2 types; Direct Connected Worm Gear Elevators, 5 types; Belt Connected Electric, 6 types; Electric Dumb Waiters; Push Button Electric Elevators; Push Button Electric Dumb Waiters; Electric Automobile and Carriage Lifts; Sidewalk Elevators and Ash Hoists.



Standard Gearless Traction Elevator, Overhead or Basement Construction. For Passenger or Freight Service. Full Magnet Control. For speeds of 400 ft. per minute or more.

HYDRAULIC ELEVATORS

Our Hydraulic Elevator is built for every purpose. The standard apparatus consists of either a plunger machine, or geared vertical or horizontal elevator machines.

STEAM TRACTION ELEVATORS

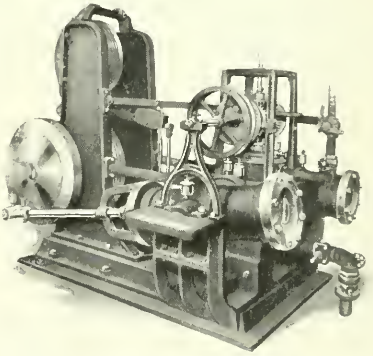
For passenger and freight service. Built either horizontal or vertical.

ELEVATOR INSTALLATIONS

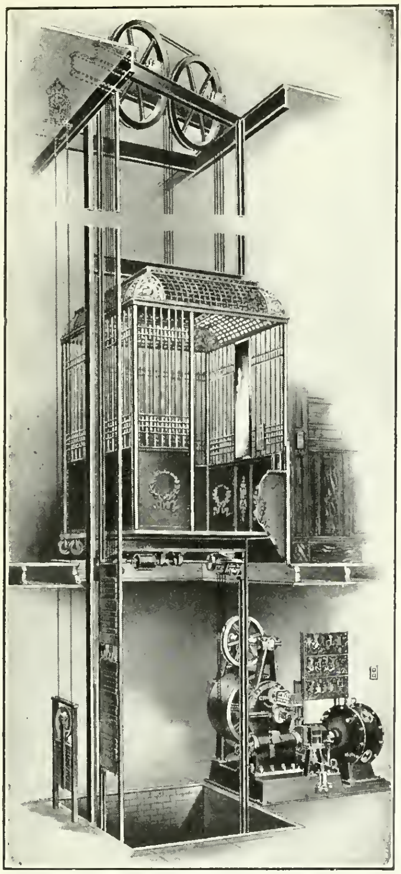
The elevator service in a modern building is a matter of great importance and we take pleasure in inviting architects, engineers and prospective customers to use our large experience in planning suitable elevator installations.

Both passenger and freight service are usually needed, therefore provisions should be made for at least two elevators designed to serve the particular needs of the building: A few of our constructions are illustrated herewith.

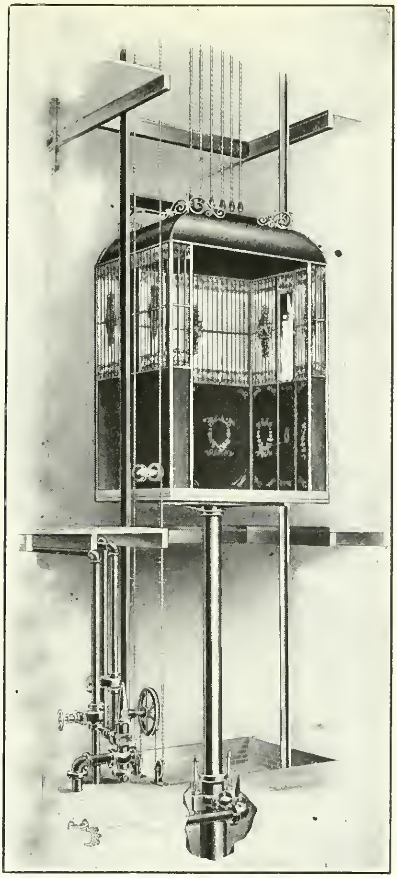
See illustrations on opposite page



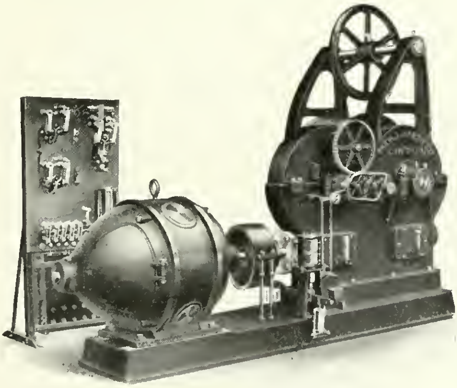
Direct Connected Steam Traction Elevator instant Speed variation from 10 to 600 ft. per minute



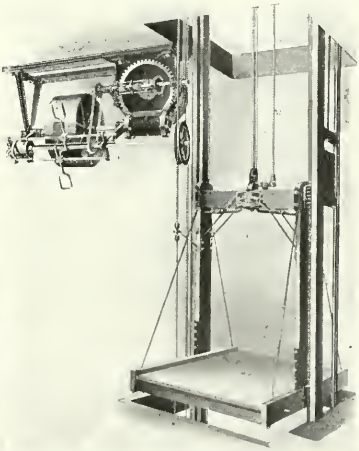
Push Button Passenger Elevator,
Full Magnet Control, Basement Construction



Hydraulic Plunger
Passenger Elevator



Tandem Gear, Full Magnet Control



Belt Connected Freight Elevator

THE TRENTON IRON COMPANY

TRENTON, NEW JERSEY

MANUFACTURERS OF THE BLEICHERT SYSTEM OF AERIAL TRAMWAYS

The Bleichert System of Aerial Tramways is one whereby the material is carried in receptacles suspended from carriages running on stationary overhead cables in a continuous circuit, the loaded carriers along one cable and the empties returning along a lighter cable parallel with this, motion being imparted by means of a light endless traction rope to which the carriers are gripped.

No matter what the contour of the ground a Bleichert tramway will take the material in a bee line from where it is produced to where it is to be delivered without rehandling at a cost of 2 cents to 5 cents per ton a mile.

Angles may be made wherever it is necessary to change the direction of the line, but should be avoided wherever possible as adding to the first cost of the line and nearly always to the cost of operating.

Intermediate loading and discharge stations can be introduced at suitable locations if required, also intermediate brake or power stations according as power is developed or required, in cases where it is necessary to divide the line into sections.

No ground is too rugged for a bee line route; no grades too steep to surmount; no rivers or valleys too wide to cross; no grading, bridges or viaducts are required.

Structures are required to support the cables. These may be spaced varying distances apart according to the contour of the ground and structures are also required for applying tension to the track cables, wherever necessary in the longer lines to maintain their proper deflection. The supports may be of wood or of iron as preferred and are designed to correspond with the service and special condition of the location.

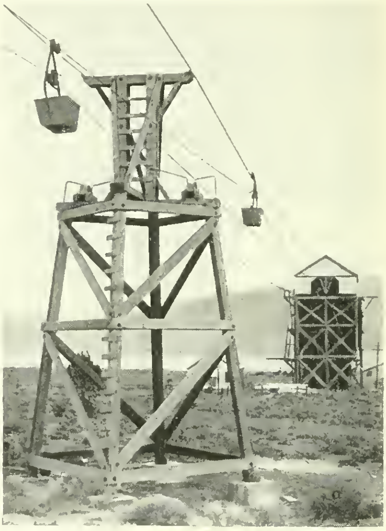


Fig. 1 Support in Bleichert Tramway

There is practically no limit to the length of a Bleichert Tramway. One line carries ore a distance of 21 miles. The loading terminal is 11,600 ft. above the discharge terminal and the capacity of the line is 40 tons per hour.

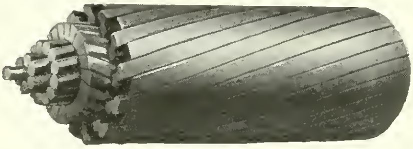


Fig. 2 Patent Locked Coil Track Cable

Fig. 3 Patent Coupling

Spans occur in this line exceeding half a mile in the clear. Spans over 1000 ft. in any line are not unusual but the spacing of the supports under ordinary conditions will average 200 to 300 ft.

The track cables are of patented locked-coil construction (Fig. 2)

THE BLEICHERT SYSTEM OF AERIAL TRAMWAYS

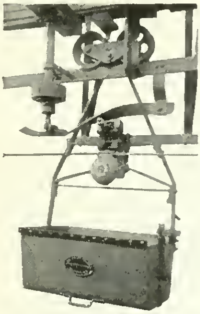


Fig. 4 Carrier with Webber Patent Compression Grip, showing patent automatic attacher

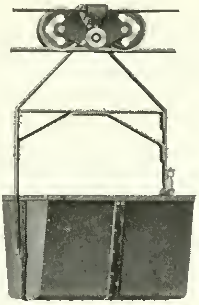


Fig. 5 Carrier with Bleichert Patent Automatic Overhead Grip

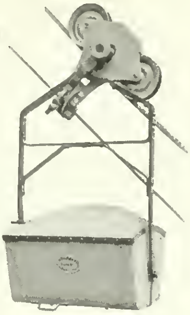


Fig. 6 Carrier with Bleichert Patent Automatic Underhung Grip

the smooth surface of which conduces toward a very uniform wear, which adds to the life of the cable and of the wheels that run on it.

These cables are made of a select grade of steel, in lengths varying from 500 to 1500 ft. which are joined by patented steel couplings illustrated in Fig. 3.

The grips for attaching the carriers to the traction rope are simple in construction, powerful, strong and efficient.

They are made for ropes running below or above the track cables according to the exigencies of the case, as shown in the cuts above. Fig. 4 represents the ordinary form of carrier with underhung grip suspended from a terminal rail, in the act of being mechanically attached to the traction rope. Fig. 5, a carrier with the Bleichert patent automatic overhead grip; and Fig. 6 a carrier with the Bleichert patent automatic underhung grip.

In the latter two the grips form an integral part of the carriage construction and operate in such a way that the weight of the carriers in any case acts as the gripping force in closing the jaws against the rope. These grips, therefore, are independent of any nice adjustment of the jaws and automatically accommodate themselves to irregularities of the rope which is a great advantage in long lines.

An overhead grip with positive operating mechanism is also made.

Well tried devices are provided for attaching and detaching the grips automatically at the terminals and other stations as may be required.

No buttons, lugs, or knots of any kind are required on the traction rope. This fact adds greatly to the life of the rope, since the wear is distributed uniformly over the entire rope and not confined to certain spots.

The same advantage pertains to these grips as compared to permanent connections of any kind. The ability to strip the line readily of its carriers when occasion occurs for resplicing the traction rope, or while making repairs is of itself a very great advantage.

Receptacles especially designed for any purpose are made of all kinds of materials. Buckets are most commonly used as shown in the illustration above, and these may be self-dumping if desired.

By cars especially designed to hold one or more buckets, the material may be transferred to and from surface tracks at the stations without rehandling.

Scales are furnished, if desired, specially designed for weighing the loaded carriers, or counters for automatically registering the number transported.

THE VAN DORN & DUTTON CO.

CLEVELAND, OHIO, U. S. A.

CUT GEARS AND PINIONS, SPUR GEARS, INTERNAL GEARS, BEVEL GEARS, SPIRAL GEARS, WORMS AND RACKS. GEAR CUTTING OF ALL DESCRIPTIONS

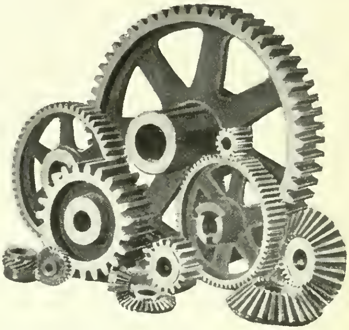
SPUR GEARS

We make and cut all kinds of Spur Gears.

In ordering gears or asking for prices please give the following data:

Outside Diameter, Pitch Diameter, Number of Teeth, Pitch, Width of Face, Diam. of Hub, Length of Hub, Projection of Hub. (outside of face), Bore of Hub, Width and Depth of Keyway. State whether gear is to be spoke or web, Material, Shaft centers.

Whenever possible, inquiries should be accompanied by a working drawing.



SPUR, SPIRAL, AND BEVEL GEARS

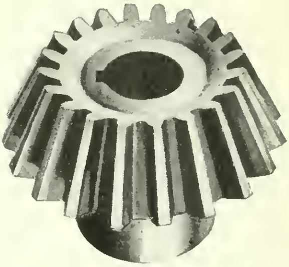
BEVEL GEARS

We have at our Plant the latest type of machines for planing teeth in Bevel Gears theoretically correct, and are in position to furnish complete gears, or plane teeth, in any kind of bevel gears required.

We do not keep bevel gears in stock, but have a number of patterns covering a variety of sizes, and are prepared to make patterns in accordance with any specifications sent us.

Blanks sent us to have teeth planed only will receive our prompt and careful attention, and when finished can be relied upon to be accurate and to run smoothly.

Always give the number of teeth in the mating gear when sending in bevel gears to replace others that are worn out.



BEVEL PINION

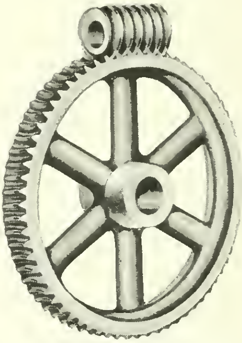
WORM GEARS

The rules for circular pitch apply in the size of tooth parts and diameter of pitch circle of worm-wheel.

To find the diametral pitch of the worm-wheel; Multiply 3.1416 by the number of threads to one inch.

Having the diameter at the throat of worm-wheel and the pitch of the worm, to find the number of teeth in worm-wheel; Multiply the diameter by the number of threads per inch on the worm and multiply this product by 3.1416, subtract 2, which will give the number of teeth.

Having the number of teeth in the worm-wheel and the number of threads per inch on the worm, to find the diameter of the worm-wheel at the throat; Add 2 to the number of teeth and multiply by .3184 and divide this result by the number of threads per inch on the worm.



WORM GEAR AND WORM

WATERBURY COMPANY

80 SOUTH STREET NEW YORK CITY

MANILA AND SISAL ROPE; WIRE ROPE OF EVERY DESCRIPTION; MUSIC WIRE;
OIL WELL LINES, BOTH WIRE AND FIBRE;
RUBBER INSULATED WIRES; LEAD COVERED CABLES

WATERBURY

TRANSMISSION ROPE

Made from highest grade of Selected Cebu Manila Hemp

This Rope is especially adapted to power driving, hoisting and other purposes where conditions require a superior Rope.

GORE CONSTRUCTION WIRE ROPE (Patented)

Made 6 strands, 19 to 61 wires to strand, according to size.

Furnished in Crucible Cast Steel, Extra Strong Cast or Plow Steel stock. The strands in this class of Rope are wound with flat wires having convex edges, which wires take the abrasion on crown of strands. The initial factor of safety is maintained longer in Gore Construction Patent than in any other class of Rope. For severe usage in Hoisting and Haulage equipments, Dredging and Steam Shovel Service.

FIBRECLAD WIRE ROPE

A combination Rope of Wire and the best grade of Tarred Russian Hemp Marline—used extensively by the United States Government, Shipbuilding Plants, Power Plants, Towing and Transportation Companies, Stevedores, Coal Companies, and in fact for all Hoisting purposes and other general uses.

NON-ROTATING ROPE

Manufactured in various grades of steel to meet working conditions. Non-Spinning or Non-Rotating Ropes are particularly adapted to work where single lines are used, and overcome the tendency of Ropes to spin, twist, or kink, with or without load.

ELECTRIC WIRES AND CABLES

Any Insulation—For Any Service

Rubber—Code-Intermediate—30% Para
Braided or Lead Encased.

Varnished Cambric—Weatherproof Braided, Flameproof Braided Station Cable, Lead Encased Underground Cable.

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Cars, Steel Dump
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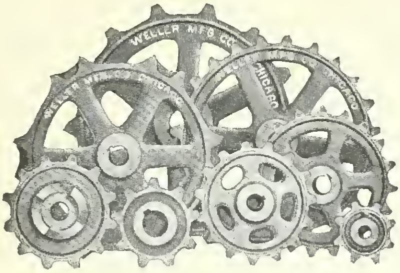

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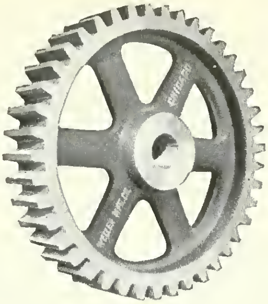

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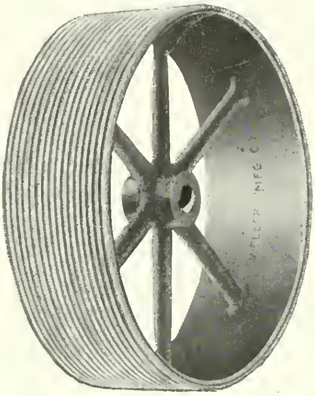

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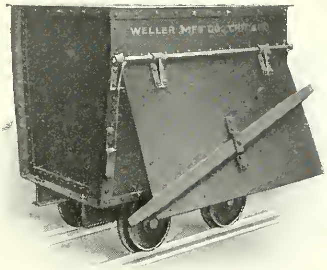

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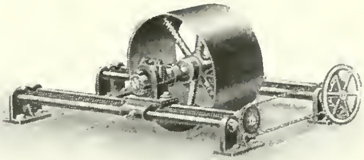

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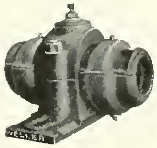

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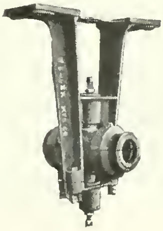
See also next page



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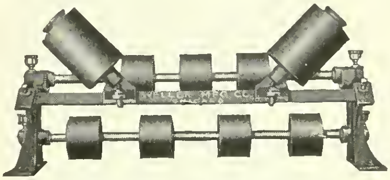

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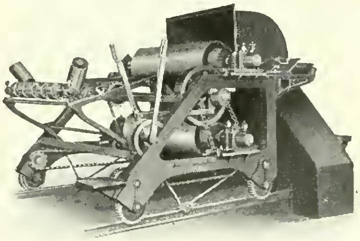

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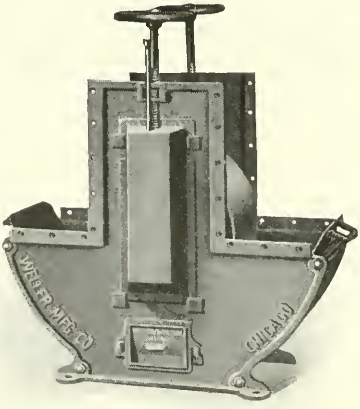

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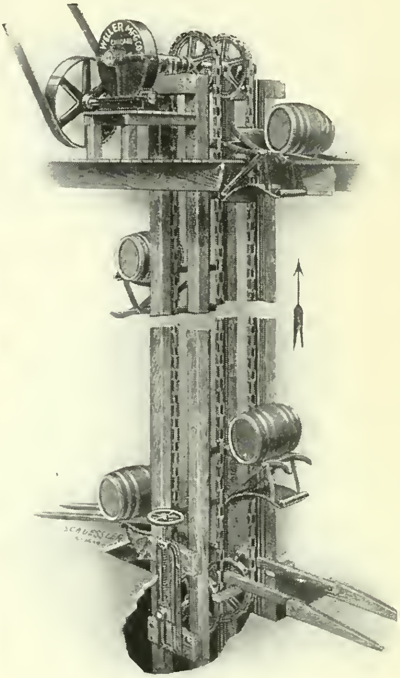

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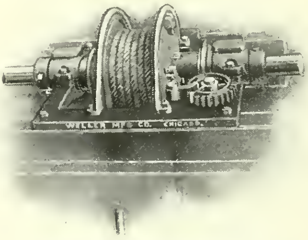

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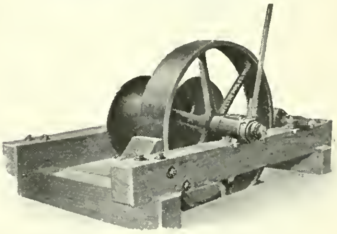

Friction Hoist

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

CONTAINING
THE PROCEEDINGS

AUGUST 1911

ANNUAL MEETING, NEW YORK, DECEMBER 5-8

AUGUST 1911 VOL. 33 No. 8

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OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

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The professional papers contained in The Journal are published prior to the meetings at which they are to be presented, in order to afford members an opportunity to prepare any discussion which they may wish to present.

The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF
MECHANICAL ENGINEERS

VOL. 33 AUGUST 1911 NUMBER 8

OCTOBER MEETING IN NEW YORK

The New York meeting of the Society to be held in October will have the following general program, subject to minor modifications. A paper will be presented by L. P. Alford, Engineering Editor of the American Machinist, and H. C. Farrell, Mechanical Engineer of the United Shoe Machinery Company, on Factory Construction and Arrangement with special reference to the construction, development and arrangement of the United Shoe Machinery Company's plant at Beverly, Mass.

Owing to the limited time, it has been decided to confine the discussion to three subjects, as follows:

- *a* Machinery Arrangement, covering the different methods of arranging machinery for manufacturing.
- *b* Artificial Shop Lighting, dealing with the advantages and disadvantages of diffused illumination, and the best type of lamps versus the advantage of individual lights at each machine.
- *c* Factory Floors, giving the relative advantages and disadvantages of concrete floors, composition floors and wood floors.

It is expected to limit the various discussions to ten minutes, making them brief and to the point, and so far as possible illustrating them with lantern slides. These are all live subjects and the Committee on Meetings of the Society in New York hopes to have a large attendance and a lively discussion.

MEMORIAL TO CHARLES WALLACE HUNT

The specially bound copies of the memorial resolutions adopted by the Council of the Society upon the death of its Past-President, Charles Wallace Hunt, on March 27, 1911, were presented to Mrs. Hunt in the name of the Society on July 16, by Past-President Jesse M. Smith, Mrs. Smith, and the Secretary.

A fund to be known as the Charles Wallace Hunt Fund, the income of which shall be devoted to the Engineering Societies Library, in which Mr. Hunt took so deep an interest, is being created by a number of his friends in the Society, as a tribute to his memory.

NECROLOGY

DOUGLASS G. MOORE

Douglass G. Moore was born at Corning, N. Y., February 26, 1846, and died at Norfolk, Va., March 7, 1911. He was educated in the public schools of Elizabeth, N. J., and in Dr. Foote's Academy, and served his apprenticeship under his father, Samuel L. Moore, of Samuel L. Moore and Company. From 1866 to 1870 he engaged in marine practice, returning in the following year to work with his father in the large machine shop and foundry of the company at Elizabethport, N. J. He sold his interest in this concern, however, to the American Shipbuilding Company when the latter firm was formed, and purchased a controlling interest in the Port Johnston Towing Company and the Poughkeepsie Brass Company, with both of which he retained active connection until his death. Mr. Moore was greatly interested in public affairs and was ever eager to adopt useful improvements.

FRANCIS SCHUMANN

Francis Schumann was born in Thuringia, Saxony, in 1844, and came with his family to America during the disturbances in 1848. Here he became interested in engineering and served throughout the Civil War as a topographical engineer on General Meade's staff, becoming engineer to the Treasury Department at Washington at its close. Eventually he resigned to become president of the Phoenix Iron Works of Trenton, N. J., leaving there in 1887 to found the Tacony Iron and Metal Company at Tacony, Pa. During his association with the company, as its president and general manager, the tower of the Philadelphia City Hall, including the William Penn statue and the smaller bronze groups, many of the United States coastwise lights, and the ornamental bronze work of the Congressional Library at Washington, were constructed. He later became president of the Pennsylvania Iron Works Company.

Mr. Schumann was a past-president of the Engineers Club of Philadelphia, the first president of the American Foundrymen's

Association, and a member of the Franklin Institute and of the American Institute of Architects. He was instrumental in founding the Tacony and the Pelham Trust companies and was vice-president of each. He died on June 29, 1911, at his home in Germantown, after a prolonged illness.

D. HOWARD HAYWOOD

D. Howard Haywood was born in London, England, March 26, 1869. He received a technical training in the Crystal Palace School of Practical Engineering during which time he spent several months in a wood-making pattern shop, machine shop and foundry. From June 1888 to May 1890 he was employed in the drafting office of Brewer and Company, engineers and contractors of New York City, and until January 1893 he was with Brown and Seward, patent attorneys. For the next seven years he conducted a business of his own in general engineering, mechanical and expert drafting work, in soliciting patents and in giving testimony as an expert in patent suits. At the time of his death, July 5, 1911, he was a member of the firm of Chapin and Haywood, New York City.

Mr. Haywood was a member of the New York Bar, NewYork County Lawyers' Association and foreign member of the Chartered Institute of Patent Agents.

ANDREW J. HEWLINGS

Andrew J. Hewlings was born in Philadelphia Pa., July 27, 1857, and received his early education in the public schools and Franklin Institute. In 1874 he entered the shops of L. Schutte and Company, where he served an apprenticeship of ten years. His later work included the erection of condensers, injectors, steam, water and air apparatus. He was president of the A. J. Hewlings Company, Chicago, Ill., until 1902, when he became manager of the catalogue department of the Crane Company, also of Chicago. This position he held at the time of his death on January 18, 1911.

TOPICAL DISCUSSION ON FUEL OIL

(Published in Condensed Form)

THE PRODUCTION OF PETROLEUM ON THE PACIFIC COAST

By Arthur F. L. Bell, San Francisco, Cal.[1]
Non-Member

Attention was first drawn in the early 60's to the presence of petroleum in California by the discovery of numerous oil seepages in Los Angeles, Ventura, Santa Barbara and adjacent counties. Most of the early drilling was confined to Ventura County and until the discovery of the Los Angeles City field no other area exceeded about 40 acres. In 1882 the Los Angeles field came in with an approximate area of 400 acres. The oil territory traversed a narrow strip in the northwestern portion of the city, crossing hundreds of city lots, so that in consequence all lot owners became oil operators or leased their lots to others. The formation was so easily drilled that portable rigs were used and in many instances wells about 800 ft. in depth were completed in a week. As late as the year 1900, a well 2000 ft. in depth was considered exceptional and there were but a few in the State, whereas today we have wells of about one mile or over in depth.

2 Such conditions resulted in an immediate over-production with a corresponding drop in price of oil from about $1.50 per bbl. previous to the discovery of the Los Angeles field, to from 15 to 30 cents per bbl. in Los Angeles in 1896. This low price caused every Southern California industry that required fuel in its operations to adopt oil on account of its cheapness and resultant saving. The real opening of California's oil industry may be said to date from the discovery of the Los Angeles field. In 1898 this field was on the wane and the price of oil rose to the dollar mark. The universal adoption of oil

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[1] The Associated Oil Co.

Presented at San Francisco meetings, December 1910 and March 1911, of The American Society of Mechanical Engineers. All discussion is subject to revision.

in Southern California had interested so many men in the industry, however, that new fields were sought with the result that the Fullerton, Coalinga, Kern River, McKittrick, and Sunset fields were immediately exploited in the order named and by 1902 the price of oil again fell to 15 and 20 cents per bbl. in the Kern field. The production of the cheap Kern River oil forced its use over the entire Pacific Coast States as well as the Hawaiian Islands.

3 It should be understood that in the early development of the oil industry the discovery of oil was greatly a matter of chance. All of the early fields, including the Los Angeles City field, Kern River, Coalinga, Sunset, etc., were discovered by drilling close to oil seepages. The Summerland field was discovered by chance through digging a water well. The Kern field was discovered by a wood chopper who having seen a small seepage on the bank of the Kern River, dug a well and with the proverbial good luck of the novice struck oil at about 75 ft.

4 Today the industry has become so well understood that, to extend the field, instead of the operator hugging the outcrop, he confidently locates his well far out in the valley or in the outlying ranges within the possible oil belt, in many cases miles from the nearest production. Where he has used fair judgment, based on the knowledge which we now have of the geological conditions of the oil measures, the chances of failure are greatly reduced. The present development of the oil industry is due, first, to the improvement in the art of drilling wells which has enabled us to reach successfully and economically depths of from 4000 to 5000 ft.; and, second, to knowledge of the oil-bearing formation, for which we are to a great extent indebted to the United States Geological Survey, which has for the last few years had a corps of geologists in the field mapping and cross-sectioning proven and possible oil territory. It is satisfactory to note that during the last year successful discoveries have been made in far outlying districts, reported as possible oil territory by the United States Geological Survey.

5 California oils are found in the territory formation in loose sandy beds. In many cases these sand strata are from 400 to 500 ft. thick, which allows for enormous storage of oil, whereas in the Eastern fields the older rocks have become so cemented and are so close-grained that there is no room for storing the oil, a difference which accounts for the small production of the Eastern wells compared with those of California.

6 In 1908, the United States Geological Survey reported 8450 sq. mi. (5,408,000 acres) of possible oil territory in the United States,

giving California 850 sq. mi. (544,000 acres), or about one-tenth of the total area, and also credit for one-half of the probable minimum oil production of the United States, or one-third of the probable maximum production. The contents of the probable oil lands of the United States in barrels of 42 gal. have also been estimated as follows:

	Minimum	Maximum		Minimum	Maximum
Appalachian..	2,000,000,000	5,000,000,000	Gulf.....	250,000,000	1,000,000,000
Lima-Indiana	1,000,000,000	3,000,000,000	California	5,000,000,000	8,500,000,000
Illinois.......	350,000,000	1,000,000,000	Minor....	1,000,000,000	5,000,000,000
Mid-continent	400,000,000	1,000,000,000	Total.....	10,000,000,000	24,500,000,000

The following shows the average daily production per well in the various fields of the United States:

	bbl.		bbl.
Appalachian..............	1.73	Illinois.................	8.73
Lima-Indiana........	2.74	Mid-continent..........	5.29
Colorado & Wyoming	8.35	Guld.................	14.08
California	42.56		

7 These were conservative estimates when made two years ago, but the development in the industry has been so rapid that they will not answer for today. I have therefore made an estimate of what I consider the proven and prospective areas of today which shows a total area of practically proven oil territory of 94,200 acres, with an estimated production of 4,319,000,000 bbl., and a probable extension of oil territory of 338,320 acres, with an estimated production of 13,258,000,000 bbl., making a grand total of proven territory of 432,520 acres and 17,577,000,000 bbl. The total consumption to date has been about 383,000,000 bbl., leaving an estimated future possible production of 17,194,000,000 bbl. Table 1 gives an itemized statement of the production by counties.

8 In submitting the above estimate of extractable oil, which is about double the estimate of the United States Geological Survey, I can only say that it is impossible for any one to state definitely what our actual production will be. I have included as possible territory only what I consider, with our present knowledge, probable territory, amounting to about 700 sq. mi., but it is quite possible that a greater acreage will be developed which will bring the total up to or over the estimate of the United States Geological Survey of 850 sq. mi., which should again increase the quantity of prospective extractable oil.

9 In the computation I have made, I have assumed the interstices in the sand to be three-tenths of its bulk and that it is filled with oil of which one-tenth would be held by capillary attraction to the

TABLE 1 CALIFORNIA'S ESTIMATED FUTURE OIL SUPPLY

County	Proven Acreage	Thickness of Sand (Ft.)	Estimated Production (Bbl.)	Possible Acreage	Thickness of Sand (Ft.)	Estimated Production (Bbl.)	Totals By Counties	
							Acreage	Production (Bbl.)
Fresno. Coalinga	29,000	50	1,128,000,000	21,440	50	834,000,000		
Kettleman Hills				20,080	50	778,000,000		
Total	29,000		1,128,000,000	41,520		1,612,000,000	70,520	2,740,000,000
Kings, Kettleman Hills				53,120	50	2,064,000,000		
Total				53,120		2,064,000,000	53,120	2,064,000,000
Kern. Lost Hills				46,080	50	1,800,000,000		
Devils Den				14,720	50	596,000,000		
Antelope Hills				16,060	50	622,000,000		
McKittrick Front	2,000	50	85,000,000	6,400	50	250,000,000		
McKittrick Front	400	150	45,000,000					
Midway Sunset	40,000	50	1,700,000,000	100,480	50	4 000,000,000		
San Emidio				12,000	50	466,000,000		
Kern River	6,000	150	590,000,000					
Total	48,400		2,420,000,000	195,680		7,734,000 000	244,080	10,154,000,000
Santa Barbara. Santa Maria	3,600	25	70,000,000					
Lompoc	1,280	25	25,000,000	2,000	50	26,000,000		
Cat Cañon	1,920	50	76,000,000	16,000	50	622,000,000		
Total	6,800		171,000,000	18,000		648 000,000	24,800	819,000,000
Southern California Fields	5,000	100	400,000,000	5,000	50	200,000,000	10,000	600,000,000
Miscellaneous	5,000	50	200,000,000	25,000	50	1,000,000,000	30,000	1,200,000,000
Total Proven Acreage	94,200							
Total Possible Acreage				338,320				
Estimated Production Proven Acreage			4,319,000,000					
Estimated Production Possible Acreage						13,258,000,000		
Final Grand Totals							432,520	17,577,000,000
Less Oil Produced to 1911								383,000,000
California's Estimated Future Supply								17,194,000,000

sand, one-tenth as readily extractable oil, and the remaining one-tenth as oil which can not be obtained. This would admit of producing about $\frac{3}{4}$ gal. per cu. ft. of oil sand, or 750 bbl. per acre foot. To substantiate these figures, I will state that prior to 1900, the Alcatraz Asphalt Company in Santa Barbara County, mechanically extracted from the bituminous sands at its Carpenteria and Sisquoc refineries, 27 per cent and 25 per cent respectively of bitumen. These sands were exposed oil sands from which the bitumen or dried-out oil was being extracted.

10 In 1901, Bernard Bienenfeld, William Mulholland, and the writer, as commissioners for the purpose of appraising the value of the different properties in the Kern field that were to form the Associated Oil Company, determined that the Kern field oil sand did contain 32 per cent of void in the sand and when filled with oil, amounted to 2.4 gal. per cu. ft. It will therefore be seen that an estimate based on an extraction of $\frac{3}{4}$ gal. per cu. ft., or 750 bbl. per acre ft., should not be considered as unreasonable if only the correct thickness of productive sands is figured.

11 To determine the life of our field, taking as a basis the figures quoted in a paper by M. L. Requa read before the California Mining Students, we would have, if we assumed the present production of 75,000,000 bbl. as the maximum consumption, $52\frac{1}{2}$ years' supply for the proven territory, and for the proven and prospective territory, less consumption to date, about 230 years' supply. If our consumption is increased, as it naturally will be, the life of our fields must be reduced proportionally. Our consumption for 1910 will amount to about 63,000,000 bbl., as about 12,000,000 bbl. will have gone into storage this year, and at the end of 1910 we will have in storage about 30,000,000 bbl., or about five months' supply. The following is a list of the recorded production of California from 1875 to 1910, inclusive, and the average daily production per well:

	Bbl. produced	Average bbl. per well per day
1875	3,000	4.11
1880	40,552	15.83
1885	325,000	38.70
1890	307,360	15.88
1895	1,208,482	13.19
1900	4,324,484	9.15
1905	33,427,473	33.49
1910 (estimated)	75,000,000	42.10
Total	382,821,212	

COMPARATIVE EVAPORATIVE VALUES OF COAL AND OIL

By C. F. Wieland, San Francisco, Cal.

Member of the Society

12 In comparing the evaporative values of the two fuels, coal and oil, it is only fair to select a coal that is considered standard and that is largely used in evaporative tests. It would not be just to select a coal of the inferior value of our Western coals, and Pocahontas coal and Kern crude oil are therefore selected as a basis of comparison, having analyses as follows:

	Pocahontas Coal, Per Cent	Kern Crude Oil, 14.5 Gravity, Per Cent
Proximate Analysis		
Fixed carbon	73.30	......
Volatile matter	17.61	......
Moisture	0.49	0.15
Ash	8.60	......
	100.00	
Ultimate Analysis		
Carbon	82.26	87.64
Hydrogen	3.89	10.48
Sulphur	0.49	1.02
Oxygen	4.12	0.08
Nitrogen	0.64	0.78
Ash	8.60	......
Sludge	......	......
	100.00	100.00

Calorific B.t.u., 14,067.

Coal data from Naval Liquid Fuel Board report, p. 10.

13 Assuming the complete combustion of the heat values in the two fuels as analyzed and knowing that 1 lb. of C requires 11.6 lb. air, 1 lb. of H requires 34.8 lb. air, and 1 lb. of S requires 4.3 lb. air, we have as the volume of air chemically required for the combustion of the coal and the oil the results shown in Table 2.

14 For our comparison we will make the following assumptions:

a Flue gas temperature is the same in both cases, viz., 500 deg.

b Moisture in the two fuels is the same.

c Air intake temperature (temperature of fireroom), 70 deg.

The flue temperature as placed at 500 deg. is probably the mean which obtains in practice; lower results have been obtained, but numerical value makes little difference in our comparison.

15 Moisture as shown in the selected coal is low and that in the selected oil is also low. In most oils it is more nearly an average of 5 per cent and for this reason we will consider that the moisture content is the same in each case.

TABLE 2 VOLUME OF CHEMICALLY REQUIRED AIR FOR COMBUSTION OF COAL AND OIL

	Weight of Air Required	
	Coal	Oil
Carbon		
Coal, 11.6 lb. air × 0.8226 lb. C	9.54	....
Oil, 11.6 lb. air × 0.8760 lb. C	....	10.16
Hydrogen		
Coal, 34.8 lb. air × 0.0389 lb. H	1.35	....
Oil, 34.8 lb. air × 0.104 lb. H	....	3.62
Sulphur		
Coal, 4.3 lb. air × 0.0049 lb. S	0.02	....
Oil, 4.3 lb. air × 0.010 lb. S	....	0.04
Lb. of air required	10 91	13.82
Weight of the combustibles (after deducting ash from coal)	0.91	1.00
Total weight which will be considered as dry chimney gas	11.82	14.82

16 The sensible heat carried away in the flue gases in the case of the coal is

$$0.24 \ (500-70) \times 11.82 = 1219.8 \text{ B.t.u.}$$

In the oil

$$0.24 \ (500-70) \times 14.82 = 1529.4 \text{ B.t.u.}$$

0.24 being the specific heat of the chimney gases.

17 In the combustion of hydrogen to water each pound of H results in 9 lb. of water, or in our coal the water formed will be

$$0.038 \times 9 = 0.34 \text{ lb.}$$

18 The heat loss both latent and sensible in the evaporation of this water is

$$0.34 \ (142 + 966 + 288 \times 0.47) = 422.6 \text{ B.t.u.}$$

wherein 212 deg. − 70 deg. = 142, assuming the temperature of the water in the coal to be that of the fireroom; 966 being the latent heat of the formation of steam at 212 deg. and of expansion against the atmosphere; 500 deg. − 212 deg. = 288 being difference between steam at 212 deg. and flue temperature as assumed; and 0.47 being the specific heat of superheated steam at atmospheric pressure.[1]

19 In case of oil we have

$$0.104 \times 9 = 0.936 \text{ lb.}$$

Heat loss is

$$0.936\,(62 + 966 + 288 \times 0.47) = 1088.5 \text{ B.t.u.}$$

The loss in coal due to ash is 8.6 per cent of total = 1209.7 B.t.u. A further loss in oil combustion is the heat absorbed by the steam used in atomizing, being in superheating the steam from 212 deg. to 500 deg. fahr. This is

$$288 \times 0.47 = 135 \text{ B.t.u.}$$

Tabulating these losses, which for convenience we will call fixed losses, we have:

	Coal	Oil
Gases	1219.8 B.t.u.	1529.4 B.t.u.
Combustion of H	422.6 B.t.u.	1088.5 B.t.u.
Ash	1209.7 B.t.u.	Burner 135.0 B.t.u.
	2852.1 B.t.u.	2752.9 B.t.u.

While this calculation is not intended to convey any idea of the actual value of losses in the two fuels, it may however afford a comparison of what we may term fixed losses, within certain limits.

20 It is seen that the amount of air required for the combustion of coal is very much less than for oil. This is due principally to the very much greater hydrogen content in the oil, the carbon content being, roughly speaking, the same. Furthermore the combustion of the hydrogen requires a proportionately larger weight of air.

21 On the other hand the greatest loss in the coal is in the ash, as in the comparison of the fuels we must consider them as received. In the oil the loss due to non-combustible is practically negligible. The loss due to superheating the burner steam is also small.

22 In examining our figures a remarkable equality of the total losses is immediately apparent. To what extent this relation would hold for coals of different composition would have to be determined. Subtracting these losses from the calorific value of each fuel we have:

$$18{,}619 - 2752.9 = 15{,}866.1 \text{ B.t.u.}$$

$$14{,}067 - 2852.1 = 11{,}214.9 \text{ B.t.u.}$$

These last quantities represent the available heat left in fuel for evaporation. From this it would appear that the two fuels under examination had an evaporative value which is in the ratio of 11.2 for coal to 15.8 for oil. For coals equal in quality to that selected, the writer believes that this ratio will generally be correct, lower grade coals having correspondingly lower values. This ratio is also amply borne out in numerous actual tests.

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[1] R. C. H. Heck. Thermal Properties of Superheated Steam, Trans. Am. Soc. M. E., vol. 30, p. 227.

23 It is shown in the foregoing that the theoretically required air supply is greater for oil than for coal. This means a greater volume of flue gases, hence a greater loss of heat. If we consider, however, those coals having a large amount of volatile matter, it is safe to say that the air supply for their complete combustion would be very much in excess of that for oil. Not knowing the composition of the volatile matter, we must necessarily figure with a certain indefinite quantity of excess air. In the combustion of oil we are able to supply more nearly that amount of air which is actually chemically required.

24 From the manner in which the oil is burned it is evident that a more perfect mixture of air with the gases is obtained. Not only is the air supply easily regulated by hand, but apparatus has been devised to effect the control mechanically and automatically to suit the momentary load requirements. Although it does not necessarily follow that a smokeless chimney signifies complete or most economical combustion, it does mean much to our neighbors and one can safely say that such a chimney is more often obtained in connection with an oil-burning furnace than with one burning coal.

25 Evaporative tests have shown that for good coal an equivalent evaporation of 11 lb. represents about the highest average, although there are cases of higher results on record. For oil the highest average yet attained is probably an equivalent evaporation of 16 lb.

26 In the report of the Naval Liquid Fuel Board the best evaporation with coal is given as 10.2 lb., while with oil the best is 14.4 lb. In some forcing tests made some time ago by F. W. Dean,[1] which are remarkable for the good results obtained at that time, an evaporation for coal of 11.32 lb. was had. In a water-tube boiler under ordinary conditions, using good coal, an average equivalent evaporation of 10 lb. can be considered good practice, although 11 lb. and slightly over is often obtained. Such results as these, it must be borne in mind,

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[1] F. W. Dean. The Forcing Capacity of Fire Tube Boilers, Trans. Am. Soc. M. E., vol. 26, p. 92.

can be obtained only with the best grades of steam coal, similar or superior to the grade selected by the writer for comparison.

27 With oil fuel, in connection with water-tube boilers, records show an equivalent evaporation of 14 to 16 lb. Test records in the writer's possession range from 13.6 to 15.4 lb. The latter is the record of the performance of a 150-h.p. Heine boiler in San Francisco. The oil used had a calorific value of 18,629 B.t.u., gage pressure 119 lb., feed temperature 69 deg., flue gas temperature 480 deg., percentage of steam used for burner 2.8 of total water evaporated or 0.36 lb. of steam per lb. of oil; 15.4 is the value after correction for steam to burner. Incidentally the efficiency of the unit is 79.8 per cent. The figures given in the foregoing for oil can hardly be said to be due to any extraordinary construction or arrangement of furnace although care may have been shown in the selection of the burner.

28 In a series of eight tests made with two 66 in. by 16 ft. horizontal return tubular boilers, having one hundred and seventy-six 2-in. tubes each, and using Coalinga oil of 22 gravity, 18,900 B.t.u. per lb. of oil, the average evaporation of water from and at 212 deg. was 15.32 lb. The average total horsepower developed at rate of 34.5 lb. of water per hour was 262.5 for the battery. The theoretical evaporation of the Coalinga 22 gravity oil, 18,900 B.t.u. per lb., being 19.56 lb. of water per lb. of oil and the actual results having been an average evaporation of 15.32 lb., the fuel efficiency for this particular battery was 78.5 per cent.

29 It is the writer's opinion that with a few more years' experience and a more refined and perfected fireroom and furnace arrangement, we will be able to reach evaporations closely approximating the theoretical limits. The ease of manipulation of the fire and the possibility of practically exact regulation of air supply for complete combustion, lend to the fuel oil evaporative qualities that can be found in no other raw fuels.

THE RELATIVE VALUE OF LIGHT OIL AS COMPARED WITH FUEL OIL

By Joseph Nisbet LeConte, Berkeley, Cal.

Member of the Society

30 Crude petroleum consists principally of various combinations of hydrogen and carbon together with comparatively small amounts of nitrogen, oxygen and sulphur. The nitrogen and oxygen and any

incombustible residue or ash may be classed as inert impurities. The sulphur, though combustible, has a low grade of heating value and is otherwise injurious.

31 Taking hydrogen and carbon as the principal constituents, it is found that those oils which are rich in the former element are of light specific gravity as compared with those rich in carbon. The range in specific gravity of California oils may be taken as from unity to 0.84, or from 10 deg. to 36 deg. of the Baumé scale. The majority of the fuel oils will range from unity to 0.9, or from 10 deg. to 23 deg. Baumé. It is also evident that, other things being equal, oils rich in hydrogen will contain more heat units per pound than those rich in carbon. Pure hydrogen contains 62,000 B.t.u. per lb., as compared with 14,500 B.t.u. per lb. for carbon. If petroleum were composed wholly of these two elements, a very consistent law might be expressed between the heat units per pound, and the specific gravity. As a matter of fact the other substances occurring in varying amounts destroy any exact relation.

32 Water in emulsion in crude oil not only acts as an inert impurity in a sample under test, but must be converted into steam in the furnace and thus still further reduces the heat value of the fuel per pound. It occurs in such variable and often in such large amounts, that no relation whatever between specific gravity and B.t.u. per pound can be discerned unless it is eliminated. In the following tables and diagrams, therefore, the oil is assumed to be anhydrous, the water having either been removed before testing, or else its amount determined and corrections made.

33 Nitrogen and oxygen are also inert impurities, but since their amounts are small, their effects are averaged in with the plotted results. Sulphur is a substance which causes considerable variation in the heating value of fuel oil. Sulphur contains 3900 B.t.u. per lb. Oils rich in sulphur, therefore, have a lower heating value per pound, other things being equal.

34 Many determinations of heating values and specific gravities of California oils have been made, but those upon which Table 3 is based were made in the chemical laboratories of the University of California and furnished through the kindness of Prof. Edmond O'Neill and his assistants. The calorific values were determined by means of an Atwater bomb calorimeter, and the specific gravity by means of a Westphal balance or a pycnometer flask at about 63 deg. fahr. Water was determined by distillation.

35 The resulting values for the heavier fuel oils the writer has

collected and plotted, as shown in Fig. 1. The ordinates in this case are degrees of the Baumé scale, which is related to the true specific gravity by the relation

$$\text{Specific Gravity} = \frac{140}{130 + B}$$

or

$$B = \frac{140}{\text{specific gravity}} - 130$$

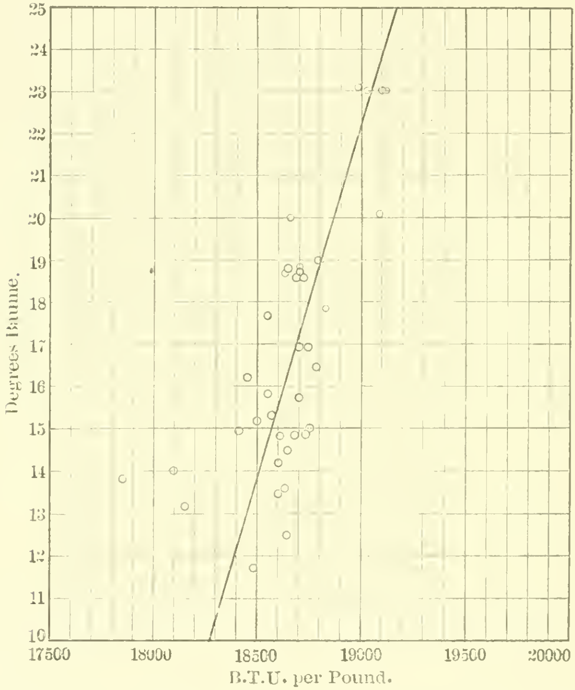

Fig. 1 Relation between Specific Gravity and B.t.u. for Heavier Fuel Oils (anhydrous)

at 63 deg. fahr. The abscissae are British thermal units per pound of the anhydrous oil. The points, as might be expected, are rather scattered, but can be approximated roughly by a straight line. In drawing the average line through these points the writer has been guided for its position wholly by the points themselves, and for its inclination, by the points and by a table of average specific gravities and calorific values furnished by R. W. Fenn of the Union Oil Company, covering a wider range of specific gravities than do the determinations gathered by the writer. The average line gives the relation

$$\text{B.t.u. per lb.} = 17{,}680 + 60\,B$$

over the range of these measurements.

TABLE 3 SPECIFIC GRAVITY, WEIGHT AND HEAT VALUE OF OIL

(UNION OIL COMPANY)

Deg. Baumé	Specific Gravity	Weight per Bbl.	B.t.u. per Lb.	B.t.u. per Bbl.	Deg. Baumé
10	1.0000	350.035	18,280	6,398,600	10
11	0.9929	347.55	18,340	6,374,100	11
12	0.9859	345.10	18,400	6,349,800	12
13	0.9790	342.68	18,460	6,325,900	13
14	0.9722	340.30	18,520	6,302,400	14
15	0.9655	337.96	18,580	6,279,300	15
16	0.9589	335.65	18,640	6,256,500	16
17	0.9524	333.37	18,700	6,234,000	17
18	0.9459	331.10	18,760	6,211,400	18
19	0.9396	328.89	18,820	6,189,700	19
20	0.9333	326.69	18,880	6,167,900	20
21	0.9272	324.55	18,940	6,147,000	21
22	0.9211	322.42	19,000	6,126,000	22
23	0.9150	320.28	19,060	6,104,500	23
24	0.9091	318.22	19,120	6,084,400	24
25	0.9032	316.15	19,180	6,063,800	25

36 Table 3 gives the computed values of B.t.u. per pound, and specific gravity, as well as the weight per barrel, and B.t.u. per barrel, as determined from this average line. From these it is seen that although the average heating value per pound of crude oil increases as the specific gravity diminishes, it does not increase so rapidly as the weight per unit of volume diminishes. The heating value per barrel of the heavier oils is therefore greater than that of the light ones.

FURNACE ARRANGEMENT FOR FUEL OIL

By C. R. Weymouth, San Francisco, Cal.

Member of the Society

37 In a paper[1] presented at the New York meeting of this Society, December 1908, the writer gave various data regarding California

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[1] Trans., Am. Soc. M. E., vol. 30, p. 797.

fuel oil, air required for combustion, the various losses in oil firing, and a description of an automatic system for the regulation of boilers fired with crude oil. Although the present subject properly includes the question of air supply for combustion, the writer, by reason of his former paper, will devote himself mainly to the question of furnace design, and this only for stationary water-tube boilers.

38 About twelve years ago the low cost and certainty of supply of crude oil led to its general use in California boiler plants. At that time with a few notable exceptions, there were none but the crudest methods for burning oil, the owner usually employing one of the numerous improvisors of oil burners to convert his plant, the operation generally consisting in introducing a burner through the fire doors, and covering the grates with fire brick. This plan was occasionally modified by the introduction of different forms of fire-brick arches, target walls, checker walls, etc. Many of these converted coal-burning furnaces caused frequent burning out of boiler tubes, due to the localization of heat; gave a very limited overload capacity; and by reason of various defects of furnace design, coupled with a general ignorance of the question of oil burning, produced in most instances mediocre results.

39 During the early period, E. H. Peabody, then testing engineer of the Babcock & Wilcox Company, began the first extensive engineering investigation of the merits of various types of furnaces, burners, etc., and after an extensive series of tests, lasting nearly two years, developed an oil furnace bearing his name, now in general use with certain types of water-tube boilers.

40 Mr. Peabody's tests indicated the following conclusions:

a That while there are differences in various types of burners, these are relatively unimportant.

b The proper design of furnace is of supreme importance as determining efficiency and capacity of boilers and immunity from shutdown, owing to tube burn-outs, etc.

c Fire-brick arches and target walls are not only needless in securing high furnace efficiency, but a menace to continuity of operation, owing to the impossibility of even the best grades of fire brick withstanding the intense heat of an oil furnace.

d Furnace depth and furnace volume are determining factors affecting furnace efficiency and capacity, and affording protection to the boiler heating surface, particularly when the character of boiler feed water gives rise to an accumulation of scale inside boiler tubes.

e The shape of furnace and path of flame must be such as to provide a nearly uniform distribution of furnace heat over the largest possible portion of boiler heating surface, as distinguished from an arrangement causing the direct impingement of flame on a few inches of the tube length.

f A large surface of heated fire brick is essential to the maintenance of a high furnace temperature and complete combustion of oil.

g The air for combustion should be admitted through carefully planned openings in the floor of furnace in such manner as to provide the most intimate contact of oil flame and incoming air, and thus reduce the air supply to a minimum.

h The flat flame or fishtail burner provides for the most economical use of air for combustion.

i When all these requirements for highest economy are observed, the furnace flame has not the bright incandescence sought by the pioneers in oil burning, but borders surprisingly on an orange red.

41 In the Peabody furnace the bridge wall is set back from the boiler front to give a depth of from 8 to 10 ft., depending on the size of boilers. The burner is of the back shot type, inserted from the boiler front under the floor of the furnace and turning up at the bridge wall. It shoots the flame forward toward the front of the boiler, where there should be an extra course of fire brick set in place without fire clay, to afford added protection to the front wall. With boilers having tubes inclined downwards from the front towards the rear, there is thus provided a furnace design of such a shape as to give the necessary increased volume as the velocity of the flame decreases in flowing away from the burner. This provides a gradual distribution of the furnace heat over the tubes the full length of furnace, without a direct impingement of flame at any point.

42 Except in special boilers, the furnace should have a height at its front end of not less than 6 ft. and for large size boilers the height should be from 7 to 8 ft., depending on the character of feed water and desired overload.

43 Under ordinary firing, the flame should not extend into the tubes, but under forced firing it will extend part way through the first pass.

44 Under Babcock & Wilcox boilers, Mr. Peabody's record performance of 1903 was 83 per cent efficiency at rating, based on 10 sq. ft. of heating surface per boiler horsepower, and an overload capacity of 110 per cent above rating.

45 When admitting a large excess of air and an ordinary amount of oil, the flame length will be a minimum, and the temperature of incandescence will be reached at the surface of the envelope separating the vaporized oil and air for combustion. This bright flame is sought by the untrained fireman, but it results in a large loss of fuel, as the subsequent mixture of the products of combustion with the excess of air not in contact with the flame produces a lower mean furnace temperature. With economical firing the flame lengthens before coming in contact with sufficient air for complete combustion, and with the highest furnace efficiency this temperature varies from 2500 to 2800 deg. fahr.

46 The location of the furnace relative to the boiler heat absorbing surface is of the utmost importance, not only on account of the loss of heat and consequent radiation from furnace walls when there is excessive travel, but also by reason of the large amount of heat absorbed by direct radiation as distinguished from convection. The first pass of the boiler should be located directly over the furnace, providing the most direct transmission of the heat generated, both by convection and absorption of radiant heat.

47 Owing to the large area of incandescent fire-brick surface, the radiant heat is uniformly diffused over a large heating surface and the amount of heat thus absorbed becomes an important factor in determining the efficiency of boiler heating surface; for while no heat can ultimately be lost, the greater the heat absorbed in the first pass of boiler, the lower will be the temperature of gases on entering the second pass; and finally the later passes of the boiler are able to accomplish greater cooling of the products of combustion, resulting in the lowest possible stack temperature and hence the maximum absorption efficiency of boiler.

ATOMIZATION OF OIL

By A. M. Hunt, San Francisco, Cal.

Member of the Society

48 In order that petroleum may be burned with complete combustion, it is necessary that it be either gasified or injected in the form of a spray into the furnace in which it is burned. If the oil is being injected into a coal furnace, that is, one not enclosed by walls of brick or other material which becomes highly heated, the oil must be injected in a spray composed of very fine particles, in order that none of the particles shall fall to the bottom unconsumed. If the walls are highly heated, the radiation from them will aid greatly in vaporizing the oil particles, and larger particles will be consumed before they drop. If the furnace is short, the oil particles will have a relatively short time period within which they must be consumed, and must, therefore, be smaller.

49 It is evident that anything which will enable the oil more easily to be atomized, or that will aid in vaporizing an oil particle after it is injected into the furnace, will help to reduce the quantity of atomizing medium required, whether it be steam or air.

50 Most of the oils used for fuel are of a heavy and viscous character, and their viscosity is rapidly reduced by rise in temperature. It is, therefore, desirable that the oil fed to the burners be preheated, and it is almost universal practice to do so. The preheating is usually accomplished by passing the oil through a heater similar in type to a closed feed-water heater, using the exhaust steam from the pumps handling the oil. The burner should be so built that the relative areas of openings for issue of oil and atomizing medium can be maintained, or if they become enlarged by scoring, that adjustment can be readily and inexpensively made.

51 Some work has been done in the direction of atomizing the oil without the use of air or steam. The oil having been preheated to temperatures of from 220 to 260 deg. fahr., is injected into the furnace through a needle nozzle, having a small sized orifice. The portion of the needle stem inside the cylindrical part of the nozzle has cut on it a screw thread, which imparts to the issuing oil a rotary motion. The release of pressure on the heated oil, and the rotary motion imparted to it, cause it to issue in the form of a spray in a state of subdivision fine enough to enable it to burn successfully.

52 I give below some data as to amounts of atomizing medium required for fuel oil, obtained from various sources:

DATA AS TO AMOUNT OF STEAM REQUIRED FOR ATOMIZING FUEL OIL IN BOILER FURNACES

Case 1	
Steam supplied to burner per lb. of oil	0.537
Actual evaporation per lb. of oil	13.48
Percentage	4.0
Case 2	
Steam supplied to burners per hour	4373.0
Actual evaporation per hour	96881.0
Percentage	4.5
Steam per lb. of oil for atomization	0.529
Case 3	
Steam supplied to burners per hour	7087.0
Actual evaporation per hour	174820.0
Percentage	4.0
Steam per lb. of oil for atomization	0.485
Case 4	
Steam supplied to burners per hour	5746.0
Actual evaporation per hour	144079.0
Percentage	4.0
Steam per lb. of oil for atomization	0.475
Case 5	
Steam used was measured by use of separate boiler.	
Oil used	34½ deg. Baumé
Total evaporation per lb. of oil from and at 212 deg.	14.99
Percentage steam evaporated, used by burner	7.4
Case 6	
Steam used was measured by calibrated nozzle.	
Total evaporation per lb. of oil from and at 212 deg.	14.7
Percentage steam evaporated, used by burner	2.5
Case 7	
Steam used was measured by calibrated nozzle.	
Total evaporation per lb. of oil from and at 212 deg.	14.2
Percentage steam evaporated, used by burner	3.6
Case 8	
Steam used was measured by use of separate boiler.	
Total evaporation per lb. of oil from and at 212 deg.	15.2
Percentage steam evaporated, used by burner	2.96

53 From tests made under the direction of the Bureau of Steam Engineering in 1902, the following data are taken: Four tests were made using steam as the atomizing medium. The percentage of

total evaporation used by the burners ranged from 3.98 to 5.77 per cent. A number of tests made under Stirling water-tube boilers gave results ranging from 2.1 to 3.42 per cent.

54 From the above data and general practice and experience, the following statement can be made: In designing a plant it is entirely safe to assume 5 per cent of the evaporation of the boilers for steam supply for burners. In operation, if the amount is greater than 3 per cent, it may be concluded that the condition can be bettered.

55 The use of compressed air for atomizing fuel oil may be stated to offer no opportunity for fuel saving over the use of steam direct in cases where steam is available. The use of steam direct obviates complication, and risk of interrupted service, and the use of compressed air is not justified unless there is some special reason for it. It may be that steam cannot readily be had, and that a motor-driven compressor can easily be installed, or where steam is available, the loss of water through steam supplied to the burners may be undesirable, as in the case of sea-going steamers.

56 In certain metallurgical and industrial operations, especially where high temperatures are desirable, the use of air is to be preferred. In rotary cement kilns, using oil fuel, compressed air as the atomizing agent is universally employed so far as I know. Reverberatory furnaces for metallurgical operations, using oil fuel, employ compressed air.

DATA AS TO AMOUNT OF AIR REQUIRED FOR ATOMIZING FUEL OIL

Case 1

Rotary cement kiln, 7 ft. 6 in. in diameter by 125 ft. in length, producing about 500 bbl. of clinker daily. Air used under pressure of approximately 80 lb. Single burner, delivering oil at the rate of about 4 gal. per min. The weight of air required for atomization is approximately 25 per cent of the weight of the oil atomized.

Case 2

Data furnished by air compressor manufacturer as to capacity of compressor furnished for boiler installation of 2500 h.p. Assuming that the entire capacity of the compressor was necessary, this figures out a use of air amounting to approximately 55 per cent of the weight of fuel atomized.

The same manufacturer gives the following data: For marine boilers figure 1 cu. ft. of free air for each 5 boiler h.p., the air being supplied at a pressure of about 25 lb.

A 10-cu. ft. compressor at 20 lb. will supply air sufficient to atomize the fuel oil to take care of a boiler furnishing steam heat for a small apartment house.

For burning sewer pipe it takes about 5 cu. ft. per min. for each burner using about 5 gal. per hr. of oil.

He adds the following comment: We favor the use of air as hot as we can get it from the compressor, cutting out the water jackets.

Case 3

Reverberatory copper matting furnace. Hearth 80 ft. long by 17 ft. wide. Center of roof arch is about 39 in. above the surface of bath on hearth. Fired from the end using four burners. Amount of material smelted per day, 182 tons. Oil used per day, 36,472 lb. Air for atomizing supplied by a motor-driven Connersville blower at 9 lb. pressure. Amount of air used, about 50 per cent of weight of oil burned.

SIZE OF STACKS WITH FUEL OIL

By K. G. Dunn, San Francisco, Cal.

Member of the Society

57 The question of stack area and draft depends on the quantity of fuel burned and the draft required. In coal burning, the draft necessary to overcome the friction of the fuel bed runs anywhere from 35 to 70 per cent of the total draft head. This is done away with in oil-burning furnaces and consequently a shorter stack will answer. A height of stack of from 80 to 100 ft. is all that is necessary. In coal-burning plants stack sizes are based on 5 lb. of fuel per boiler h.p. In changing to oil we have to figure on the basis of only 2½ lb. per boiler h.p., and considering that oil can be burned with a smaller amount of excess air than coal, a stack of given area would serve for double the horsepower with fuel oil than it would with coal.

58 There are many stacks operating successfully on the basis of 50 per cent of the sizes given in Kent's table. I have in mind a record of one stack which, when forced to the limit, operated on the basis of 35.7 per cent. When this point is reached the pressure in the furnace is so great that the gases pass out through the joints in the setting and through the boiler breeching. One point in connection with this, which I believe is not given the attention that it should have, is that of breeching area. Ordinarily the effective area of the breeching is not considered, as in many plants the breechings are narrow and long, and in several instances that I know of, the effective areas are in the neighborhood of 70 to 80 per cent of what they really should be.

LOCOMOTIVE PRACTICE IN THE USE OF FUEL OILS.

By Howard Stillman, San Francisco, Cal.

Member of the Society

59 About the first practical use to which fuel oil was applied as a means of generating steam in California was on a locomotive engine of the Central Pacific Railroad, in 1886, the tests being made between Sacramento and Davisville. The oil was comparatively thin and of a reddish color, and was, I think, a foreign product. The experiments as I remember, were quite satisfactory, but the price of this oil was high and the matter was dropped.

60 Following the subsequent oil developments in California and the promise of a sufficient supply, a continuation of the early experiment was made and tests indicated great possibilities for this fuel. The first regular conversion of a locomotive to oil burning in regular service was on the Southern Pacific Railroad in November 1900 and a number of tests made in comparison with coal fuel proved so satisfactory that, in February 1901, we were authorized to equip other engines. This was gradually done, and in about five years all locomotives were converted to oil burners on the Southern Pacific in California, and extending to El Paso, Texas, embracing what are known as the Calvin Lines. The approximate number of locomotives we now have burning oil is as follows:

Passenger	396
Freight	455
Switch	140
Total	991

61 On the above basis the consumption is 677,875 lb. per month, or 8,134,500 bbl. per year. These figures are for about six months ago and are slightly exceeded at this time.

62 The characteristics of the oil have been fully covered in the previous papers. There is, of course, a slight variation in specific gravity ranging from 14 deg. to 15 deg. Baumé. Its calorific value is taken at 18,500 B.t.u., which we consider to express its heat value. The following specifications for fuel oil have been adopted by the Southern Pacific system:

General Requirements. Liquid fuel is crude petroleum as received from the wells, or the product of crude petroleum, distilled or reduced. It must contain no sand or foreign matter in the shape of sticks, waste, stones, etc., and must be sufficiently liquid to flow readily in 4-in. pipes at a temperature of 70 deg. fahr. It must contain as little water as possible, and oil containing more than 2 per cent of water and other impurities will not be accepted.

Fuel oil will be paid for on the basis of volume at 60 deg. fahr., also deducting all water contained, according to method outlined as follows:

Tests. One sample will be taken from each carload or fraction thereof. The sampling of cars is to be made with car thief having valve at lower end. The thief with open valve will be lowered gradually into car and valve closed at instant of touching bottom. The thief thus filled will contain oil sample to be tested for water, sand, basic sludge, and specific gravity.

Oil received in settling or storage tanks will be sampled with Robinson or other standard thief, a sufficient number of samples being taken to secure an average of its contents.

Fuel oil will not be accepted for general use, the flash point of which is less than 110 deg. fahr. when tested by the open cup, Tagliabue method. The oil to be heated at rate of 5 deg. per min., and test flame applied every 5 deg., beginning at 90. This flashpoint being the danger point at which the oil begins to give off inflammable gas, the fire or burning point is not required.

The test for water, sand, and Baumé specific will be made as follows: 100 cu. cm. of the sample will be placed in a 250-cu. cm. graduated glass cylinder provided with stopper, and thoroughly shaken up with not less than 150 cu. cm. of gasoline. The mixture will be heated to 120 deg. fahr. for from 3 to 6 hours to facilitate the separation of impurities, the amount of which can then be read from the graduations of cylinder. All proportion of water and other impurities contained in the sample will be deducted from the volume contained in the car and not paid for.

The temperature of shipment will be tested directly as sample is removed from sampling tube, or by immersion of thermometer in the receptacle itself for not less than one minute. A deduction in volume for expansion at temperature of over 60 deg. fahr. will be made at rate of 0.0004 for each degree. At 90 deg., the deduction would be $1\frac{1}{5}$ per cent, etc.; Kansas and Oklahoma fuel oil furnished from Sugar Creek or Kansas City, Mo., at 90 deg., should have a deduction of $1\frac{1}{4}$ per cent.

Gravity of fuel oil should range between 13 and 29 deg. Baumé at 60 deg. fahr.

Conditions. If any portion of an accepted shipment is subsequently found to be damaged, or otherwise inferior to the original sample, that portion will be returned to the shipper at his expense. Any sample failing to meet all the requirements of this specification will be condemned, and the shipment represented by it will be returned to the manufacturers, they paying freight both ways.

63 In the evolution of oil burning in locomotives, the matter unfortunately resolves itself to one of local conditions. The modern locomotive boiler is not an ideal form of oil furnace. Railroads must

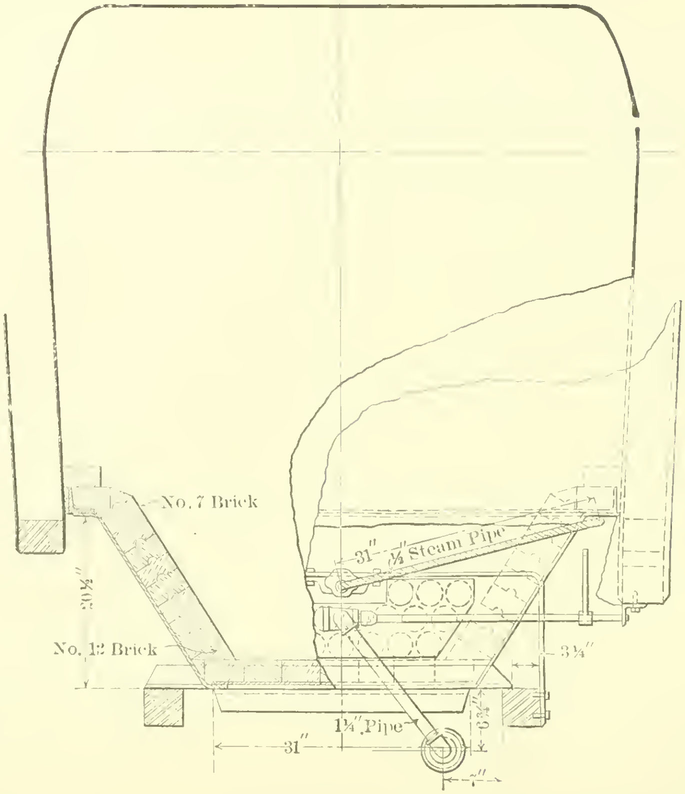
burn whatever fuel is cheapest and most available, and the matter continues to be one largely of expediency.

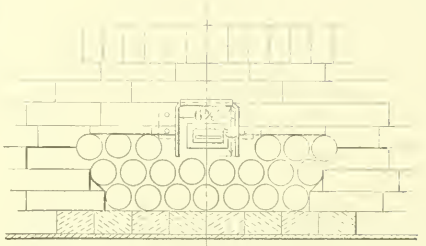
64 Locomotive boilers are designed for coal fuel and it was formerly boasted that should emergency arise the oil burners could be converted over night in the roundhouse back to coal again. From the figures given us by Mr. Bell it does not seem at all likely that the contingency will soon arise.

65 Locomotive fuel oil is carried in tanks built to fit the coal space in the tender. Additional flat tanks when required are placed over the coal space or back of it. Gravity supply is depended upon through flexible pipes to the locomotive. Each system of oil tanks on the tender is provided with a gage board or scale from which the fuel records are kept.

66 The burner used is of the flat jet type consisting of a flat casting divided longitudinally by a partition over which the oil flows as it is admitted to the upper cavity. The lower cavity receives the steam for the jet which strikes the oil flowing over the partition, spraying it into the furnace. We aim completely to atomize the oil near the burner tip in order that it may be immediately vaporized. The form of burner is of little importance provided it is simple, easy to clean, and without complication from carbonizing. It has in truth been said that those who try to improve the efficiency of fuel oil by alteration of the burner are on a plane with those who try to improve the steaming quality of a boiler by altering the injector. High efficiency from fuel oil is due mainly to the arrangement of the furnace.

67 The steam for atomizing is obtained from the dome and is available at full boiler pressure of 200 lb. through a suitable regulating valve. We have used compressed air experimentally and for some time used a form of burner that delivered air inductively to the burner itself. Other than by a localization of heat at the point of the burner, no benefit could be found by tests with air mingled with the steam in this way. Atomization with compressed air is undoubtedly of value under certain conditions but is liable to produce locally in the furnace a more intense heat than is desirable. With the steam jet the oil is sprayed and broken up so as to allow the air admitted through proper dampers to mix and the oil to be consumed completely without damage to the sheets. Tests on our locomotives by Professor Grey, formerly of the University of California, show that temperatures ranging from 2500 to 2750 deg. fahr. are obtained, the latter being the highest observed.





No. 11 Brick used for Filling in where Necessary

Bill of Brick	
No. 7	365
No. 11	6
No. 12	20
Plain Brick	58

Fig. 2 Cross-section of Locomotive Firebox, showing Method of Fitting for Oil Burning

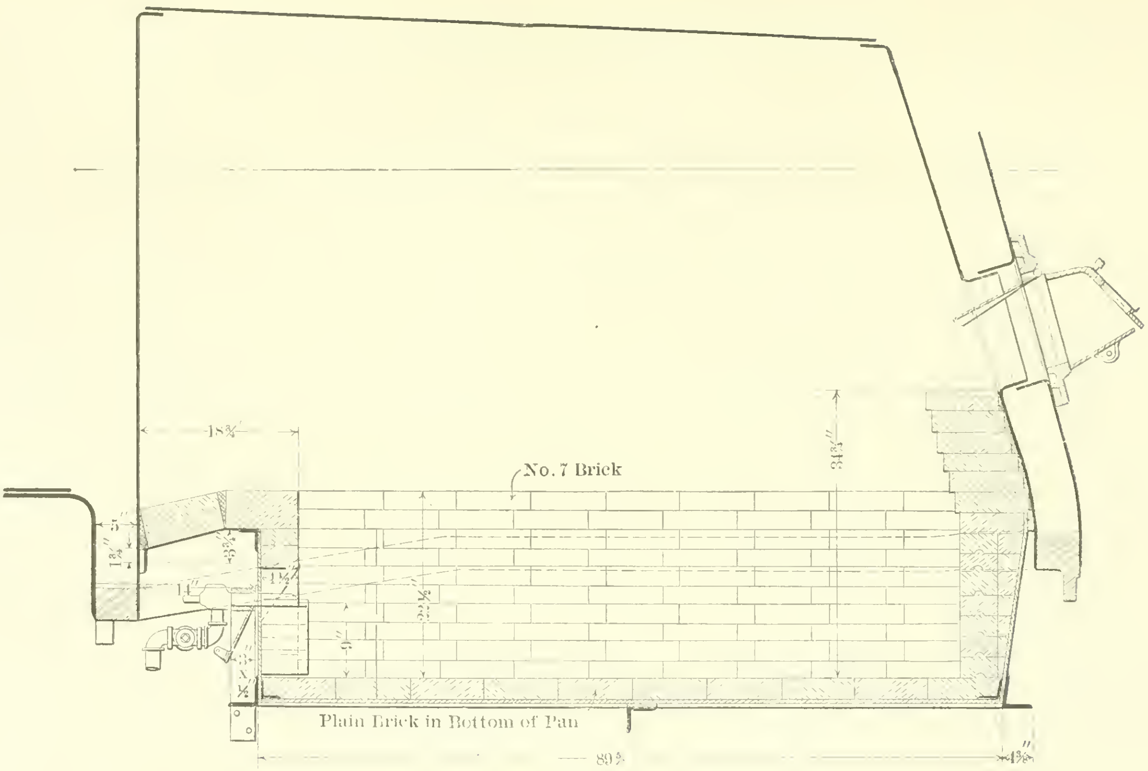


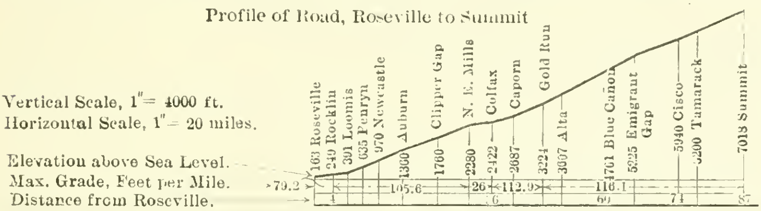
FIG. 3 LONGITUDINAL SECTION OF FIRE BOX

68 The method of fitting a locomotive fire box for oil burning is shown in Figs. 2 and 3, which is the present standard arrangement for our heavy freight engine of the consolidated type. Fire bricks, the most refractory obtainable, are placed at the lower side of the fire-box plates to prevent impinging of the oil blast against the sheets. No more bricks than are necessary for the purpose are used. The most refractory bricks melt out in a comparatively short time—not from an intense degree of heat but from the fluxing agents introduced with the oil, especially salt or other alkalis with which California petroleums are associated.

69 Fire-box repairs to oil-burning locomotives do not exceed those of coal-burning engines. From records kept of cost of maintenance, we know that if a furnace is properly equipped with draft adjustment and burner, an oil-burning fire box will outlast a fire box burning coal; that is, on the same class of engines in the same service. However, it cost a good many fire boxes to determine the best arrangement. In this connection I wish to emphasize the fact that the oil fireman is a large factor in successful oil burning on locomotives. The condition is very different from that of oil firing on stationary boilers. Conditions are constantly varying in the locomotive engine, depending on load and speed, regularity of service, condition of track, grade and rules of the road. The oil fireman must necessarily watch the operation of the locomotive with intelligence and every movement of the engineer demands corresponding regulation of the fire and watchfulness on the part of the fireman. He has two gages to guide him, the steam gage and top of the stack to show results, the desired steam pressure with least smoke being the objective. It is a general though not universal condition that the locomotive should give some smoke. In general a thin grey smoke is indicative of the most economic result. A careless fireman can do great damage to the fire box and flues if he neglects to attend to the dampers and regulators at the proper time.

70 It is my opinion that a greater depth of fire box is more essential for economic oil burning than for coal. If combustion is not approaching completion when the gases enter the flues, the vapors in process of combustion fall in temperature below that required for oxidation of the carbon, which is precipitated as soot or black smoke. While this is a common phenomenon of smoke production with any fuel, it is more in evidence with oil than with solid fuel where there is nothing to burn but volatile combustible. Lack of oxygen is generally supposed to be the cause of smoke, but lack of proper tempera-

TABLE 4 DATA FROM EVAPORATIVE TESTS OF LOCOMOTIVES CROSSING THE SIERRA NEVADAS; SACRAMENTO DIVISION, SOUTHERN PACIFIC COMPANY



Class of engine	10 wheel	Consolidation	Mallet consolidation
Service	Passenger	Freight	Freight
Date of test	May 21 and 26, 1908	June 9 and 11, 1909	Nov. 6 and 8, 1909
Number of single trips in test	2	2	2
Total time of test	17 hr. 39 min.	21 hr. 23 min.	29 hr. 2 min.
Actual running time	13 hr. 55 min.	12 hr. 59 min.	18 hr. 11 min.
Miles run	315	174	174
Average steam pressure (gage), lb	196.0	196.1	194.5
Smoke box temperature, deg. fahr.	797	738.5	451.3
Total gal. water evaporated	44147	48103	91087
Total lb. water evaporated	367642	400858	759058
Total gal. oil burned	3951.6	4328.4	7692.1
Total lb. oil burned	31613	34627	61537
Equivalent evaporation, lb. water per lb. oil	14.14	13.95	15.04
Lb. water evaporated per sq. ft. heating surface per hr.	8.698	8.809	6.392
Lb. oil burned per sq. ft. heating surface per hr	0.748	0.761	0.518
Number of cars in train	7	14.5	24.5
Weight of train, tons	342	481	1056
Gross ton mileage	107730	83694	183744
Gal. water evaporated per 1000 ton mi.	409.79	574.75	495.73
Lb. water evaporated per 1000 ton mi.	3413	4790	4131
Gal. fuel oil burned per 1000 ton miles.	34.90	48.40	39.51
Lb. fuel oil burned per 1000 ton miles.	279.20	387.20	316.08
Boiler efficiency, per cent	73.84	72.83	78.52
Maximum i. h. p.	1719	1470	2486
Mean i. h. p.	1368	1222	2057
Dimensions of locomotive			
Engine no	231	2564	4001
Size of cylinders, in	22×28	22×30	26 and 40×30
Diameter of drivers, in	63	57	57
Total weight of locomotive, lb	203300	208000	425900
Weight on drivers, lb	160000	187000	394150
Weight of tender, lb	138070	134745	169765
Total heating surface, sq. ft	2994	3403	6394
Feed water heater, heating surface, sq. ft.			1221

NOTE.—Train weights are the average for the distance hauled and are exclusive of engine and tender. Tests made under ordinary service conditions. Engines unaided. In "water evaporated and oil burned per sq. ft. heating surface per hr.," the figures are for actual running time; the allowance of 15 gal. of oil and its equivalent in water is made per hr. while standing. In "gal. and lb. oil per 1000 ton mi.," a deduction is made of 15 gal. per hr. while standing and 3.5 per cent of oil for evaporating steam for atomizing oil. Quantity of oil burned corrected to normal temperature of 70 deg. fahr. All measuring instruments calibrated. Analysis of fuel: Kern River oil; gravity, 15.8 deg. Baumé; flash point, 230 deg. fahr.; fire point, 278 deg. fahr.; commercial weight, 8 lb. per gal.

ture required for chemical combination is as often, if not oftener, the cause. The lack of sufficient fire-box volume is, in my opinion, the common cause of smoke in oil-burning locomotives when the greater demands are made on the boiler for rapid evaporation. The deposit of soot upon locomotive flues is a common difficulty and calls for the regular operation in service of sanding the flues. Soot is a poor conductor of heat and the steaming quality of a locomotive rapidly falls off when flues become lined with soot. The operation of sanding consists in dropping a reverse lever, if possible while the engine is running, pulling the throttle wide open, while the fireman puts a few cupfuls of sand through the opening in the fire door, the draft carrying the sand through the flues and ridding them of soot, the operation being repeated if necessary. A supply of sand is carried on the foot board for this purpose.

TABLE 5 COMPARATIVE TESTS WITH OIL AND COAL

Type of Locomotive	Number in Service	Evaporation, 2000 Lb. Coal Equivalent to Fuel Oil, Gal.
Eight-wheel 18-24	50	144
Ten-wheel	294	151
Mogul	176	146
Twelve-wheel	67	158
Consolidation	139	162
Atlantic	19	144
Mallet Consolidated	17	No coal record

71 In oil burning the factor of grate surface disappears. The grates are bricked over and air admission regulated through openings and proper dampers. There is no function corresponding to grate surface such as used in connection with coal burning. Only the item of heating surface remains on which to base comparisons.

72 The rate of combustion on the locomotive, like other functions, depends on the service and size of the machine. While the principles of combustion do not vary in locomotive boilers from those in stationary service, there is a wide variation in the rate of steam production, independent of the kind of fuel used. With the modern locomotive in main line service the demand for steam at full pressure per unit of heating surface far exceeds, in point of time, the product of a stationary boiler. The demand on the locomotive is intermittent and conditions vary from an enormous rate of steam production when working at a rate of maximum effort, to one of comparative rest.

73 A large number of locomotive tests have been made by the Southern Pacific Railroad, covering the use of fuel oil as well as in comparison with coal. Table 4 shows evaporative results on most recent tests covering about the heaviest oil firing which we have, crossing the Sierra Nevadas.

74 Comparisons of coal and oil from an economic standpoint are most interesting where the two fuels come in competition, and relative values must largely depend on the conditions and form of boilers under which either fuel is burned. Some engine boilers are better adapted for coal than oil, or vice versa, depending on construction. Comparisons therefore are to some degree a function of the boiler itself. This was gone into quite thoroughly when the locomotives were converted and a summary of the results is given in Table 5. The figures are based on evaporative tests before and after conversion. The comparisons are with ordinary bituminous coal of about 13,350 B.t.u.

TABLE 6 RECORD OF COAL BURNED DURING LAST SIX MONTHS OF 1901, AND OIL BURNED DURING LAST SIX MONTHS OF 1908, ON STEAMERS OF SOUTHERN PACIFIC COMPANY

Steamer	Tons Coal Consumed Last Six Months of Coal Burning	Mileage for Corresponding Period	Miles per Ton of Coal Consumed	Barrels Oil Consumed, Six Months (42 Gal. per Bbl.)	Mileage for Corresponding Period	Miles per Bbl. of Oil Consumed	Equivalent of One Ton of Coal for Equal Mileage in Bbl. of Oil
Berkeley........	2764	18592	6.72	11207	21130	1.89	3.56
Piedmont.......	4223	19548	4.63	15414	20808	1.35	3.43
Oakland	3209	18348	5.72	13603	19894	1.46	3.92
Bay City.......	2889	21536	7.45	11548	20943	1.81	4.12
Encinal.........	3703	20284	5.47	10512	19678	1.87	2.93
Newark.........	1860	9372	5.04	6559	10631	1.62	3.11
Transit.........	2581	16715	6.48	9548	17922	1.88	3.45
El Capitan.....	1019	7238	7.10	3431	6072	1.77	4.01
Solano..........	4516	5480	1.21	17151	7143	0.42	2.88
Apache.	1971	18992	9.64	7996	21380	2.67	3.61
Modoc..........	2265	20685	9.13	7682	21170	2.76	3.31
Totals and Resultant Means	31000	176790	5.70	114651	186771	1.63	

Mean Equivalent of 1 Ton of Coal in Bbl. of Oil, 3495

75 The total number of locomotives accounted for in Table 5 is 745, and the mean equivalent is 152 gal. or 3.62 bbl. of 42 gal., equivalent in heat value to 2000 lb. of coal. The average equivalent figures in the table cover much careful work and are based on equivalent evaporative results from many service tests.

It should be borne in mind that the figures are from service tests and represent oil burned on the main line between terminals only and not losses in transfer, handling or firing up, etc. Our accounting department uses a figure of 168 gal. or 4 bbl. of oil, equivalent to one ton of coal.

76 It may be said that with fuel oil, providing engines are burning it with a fair degree of efficiency, the quality of fuel is a constant factor. Poor or bad coal as accounting for engine failures drops from the delay report—"cleaning fires" is abolished.

77 Concerning relative values of coal and fuel oil I cannot close without submitting Table 6, showing results with both fuels on the Southern Pacific Company's bay steamers, the figures comprising the last six months' record with coal for the year 1901 compared with the last six months in oil for the year 1908.

78 These figures are not from evaporative tests but cover the service of eleven steamboats, a total of 176,790 miles as coal burners, and 186,771 miles as oil burners, and are from the official accounting record.

79 The service of these bay steamers represents a consumption per year of 229,302 bbl., which, added to my former figure per year for locomotives, gives a total of 8,363,802 bbl. per year consumed by the Southern Pacific Company. In addition to this a considerable amount is used in shops and rolling mills.

80 Let us hope that the rate of production in California as shown in Mr. Bell's paper, 63,000,000 bbl. in 1910, may keep up. Approximately one-seventh is consumed by the Southern Pacific Company.

MARINE USE OF FUEL OIL

By J. H. Hopps, San Francisco, Cal.

Member of the Society

81 As a fuel for steamships, petroleum has many advantages besides that of low cost, the most important of these being:

a The saving in labor and consequent reduction in the number of firemen. The amount of money saved varies with the size of the ship and the number of firemen carried. In installations of average size, one-third the number of firemen and coal passers necessary when burning coal would be sufficient.

b Reduction in weight and bulk of fuel, giving increased cargo capacity and resultant greater earning power. Comparing "Wellington Screenings," a type of coal generally used for steamship work on the coast, and fuel oil at from 14 to 17 Baumé, oil for equal heating value occupies about one-half the space taken by the coal and has less than one-half the weight. Oil may be carried in parts of the ship not otherwise useful.

c Saving in time. The time consumed in coaling and expense of moving to bunkers is saved, as fuel oil can be pumped into the ship when at the dock and while the cargo is being taken on or discharged.

d Uniform steaming. The rate of steaming can be kept uniform, there being no loss due to cleaning fires, etc.

e Cleanliness, due to the absence of coal dust and dirt when coaling and to the absence of ashes in the fireroom.

f Reduced cost of maintenance. Fewer repairs on boilers due to uniform temperature in furnace and combustion chamber. No corrosion of floor plates, fire fronts, or bunkers. No grate bars to burn out, fire doors or ash-handling machinery to renew or repair.

82 That the advantages of oil as fuel are recognized is evident from the large number of steamers using this fuel. Some of these vessels are of large size and make long voyages, notably, the ships of the Hawaiian American Steamship Company, the steamers Tenyo Maru and the Chiyo Maru of the Toyo Kisen Kaisha Company, the steamers Sierra and Mariposa of the Oceanic Steamship Company and the numerous large tank steamers owned by the Standard Oil, Associated Oil and Union Oil Companies.

RESULTS OF TESTS

83 It is not possible to give exact figures upon the saving effected by the use of oil as the prices of both coal and oil are constantly changing. Some instances, however, may be quoted.

84 In the report of the Naval Liquid Fuel Board published in 1904, figures are given upon the performance of the Steamship Nevadan of the Hawaiian American Steamship Company. The following tabulation is taken from these, voyage No. 1 with coal being from San Diego to New York and voyage No. 2 with oil from New York to San Diego.

	Total I. h.p.	Fuel	Total Consumption of Fuel	Coal per I. h.p.	Oil per I. h. p.
Voyage No. 1.....	1833	coal	2269 tons	2 lb.	......
Voyage No.2......	2196	oil	9126 bbl.	......	1.1 lb.

85 Of the coal burned, part was Eureka and part Coronel coal. The heat value of the coal is not given. The figures for voyage No. 2 represent an exceptionally fine performance. The steamer was new, fitted with triple-expansion engines, the Howden system of forced draft, and the Lassoe-Lovekin oil-burning system.

86 When burning oil, six men were required in the fireroom as against fifteen when burning coal. Four hundred and fifty-seven tons of measured space for cargo was saved on account of the decreased bulk of the oil fuel. The financial gain to the company from all causes is given as $500 per day.

87 In the case of a small coasting steamer coming under the observation of the writer, careful records were kept of the fuel cost, both with oil and coal. The cost of fuel per hour of actual steaming, averaged for a period of six months in each case, was

Coal at $5.25 per ton....................................	$2.65 per hr.
Oil at $0.70 per bbl..	1.64 per hr.

88 In 1903 a series of tests were made by T. W. Ransom on the tugs Richmond and A. H. Payson, owned by the Santa Fé Railroad Company. As these vessels ply only on San Francisco Bay and in smooth water, the installation of platform scales to weigh the feed water and fuel oil was feasible. The tests were made with great care, a number of observers being employed and all essential data recorded to show the efficiency of the entire installation and of the boilers and engines separately. The detailed data secured were destroyed in the fire of 1906, there remaining only a summary of the results.

89 The machinery of the two vessels is identical with the exception of the boilers. The Richmond is fitted with a boiler of the Scotch marine type, 13 ft. mean diameter by 11 ft. long, with three Morrison furnaces, 3 ft. 6 in. in diameter by 7 ft. 10 in. long, and 230 tubes 3½ in. in diameter by 7 ft. 10 in. long. The depth of the combustion chamber is 36 in. and the total heating surface is 2136 sq. ft. The A. H. Payson is fitted with a Babcock and Wilcox marine water-tube boiler, total heating surface 2770 sq. ft. The engines in both cases are compound engines, high-pressure cylinders 20 in. in diameter, low-pressure cylinders 42 in. in diameter, and stroke 24 in.

90 A large number of tests were made on these vessels in actual service when towing car floats to and from Point Richmond. In addition, a 5-hour test running steadily without a tow was made on each boat, with the results given in Table 7.

91 From examinations of the logs of numerous steamships, it appears that with vessels fitted with triple-expansion engines developing from 1000 h.p. up, with everything in first-class condition, the fuel consumption will be about $1\frac{1}{4}$ lb. of oil per i.h.p-hr. For smaller vessels fitted with compound engines, the consumption will range from 1.6 to 2 lb. per i.h.p-hr., depending on the efficiency of the plant.

TABLE 7 RESULTS OF FIVE-HOUR TESTS

Five-Hour Run, Tug A. H. Payson, Aug. 2, 1903

Time	R.p.m.	H.p.	Water used	Oil used	Water evap. actual	Water evap. from and at 212 deg.	Factor of evap.	Water per I.h.p.	Oil per I.h.p.	Speed knots
11.00										
12.00	95.3	535	11475	853	13.4	14.68	1.095	21.4	1.59	
1.00	96.0	523	11326	837	13.5	14.77	1.094	21.6	1.60	
2.00	94.5	509	11418	809	14.1	15.32	1.087	22.4	1.58	11.72
3.00	95.5	498	11300	826	13.6	14.66	1.078	22.9	1.65	10.63
4.00	96.4	537	12251	845	14 6	15.84	1.085	22.9	1.56	11.65
Five-Hour Run, Tug Richmond, Aug. 24, 1903										
12.00										
1.00	91	418	9532	829	12.2	12.80	1.140	22.8	1.98	
2 00	92	424	10331	835	12.4	14.10	1.143	24.3	1.97	
3.00	91	418	8831	806	11.0	12.55	1.140	21.1	1.92	11.08
4.00	91	418	10496	833	12.2	13.90	1.140	25.1	1.99	10.04
5.00	91	418	9627	865	11.2	12.90	1.150	23.0	2.06	10.75
Average For Five Hours Run										
Payson	95.5	520	11553	834	13.8	15.05	1.089	22.2	1.59	11.15
Richmond	91	419	9743	833	11.8	13.05	1.142	23.2	1.96	10.47

OIL STORAGE

92 In order to render a fuel oil installation safe, careful attention must be paid to the construction of the tanks in which the oil is stored. Not only should the very best workmanship, the best methods of support and the best quality of riveting be insisted on, but great care should be exercised in the design of the ventilation

system. Air pipes should be fitted to all tanks of sufficient size to lead off gases as they accumulate and to prevent any undue pressure on the tanks due to too rapid pumping when they are being filled. The ventilating pipes should be led as directly as possible to above the uppermost deck of the vessel. They should not be near the smoke stack and should be placed where it will be impossible for a naked light to be near them. The openings should in all cases be covered with wire gauze carefully secured. Further than this, the workmanship on all pipes, valves and fittings should be of the very best quality. Great care should be taken that all joints are perfectly tight, as the leakage of a very small quantity of oil may result in a formation of a large volume of gas from which a disastrous explosion or a serious fire may result.

93 In the case of wooden vessels, separate steel tanks independent of the structure of the ship are provided. The location of these tanks varies greatly, depending on the trade in which the ship is engaged and the preference of the superintending engineer. They are frequently placed in the space formerly occupied by the coal bunkers, in the fore-peak and, often, on deck.

94 In a steel vessel fitted with double bottom, the fuel oil may be stored in the compartments in the double bottom usually devoted to water ballast, or in deep tanks constructed for the purpose and usually extending entirely across the ship. Where deep tanks are used, expansion trunks should be provided.

95 The use of the double bottom for fuel oil is open to several objections. The tanks being shallow and divided into a large number of compartments by the floors, keelsons, and intercostals of the ship, it is very difficult to fill them completely owing to the air trapped in the different compartments. It is also impossible to empty them entirely and when a tank is only partly filled, trouble may be experienced in pumping out the oil when the ship is rolling. Again, if the ship has to go far North or South where the water is cold, the oil in the double bottoms congeals and difficulty is experienced in pumping. With many cargoes it is necessary to fill the compartments of the double bottom with water ballast when the oil is pumped out, and this means that at all times there will be a considerable quantity of water present in the oil. When the double bottom is used, it is necessary to provide settling tanks in or near the fireroom into which the oil is pumped from the ballast tanks before being pumped to the burners. The object of these settling tanks is to permit the removal of any water which may have found its way into the oil tanks, or

which may be in the oil when it is loaded. These settling tanks should be of sufficient size to contain from 8 to 12 hours' supply. They should be in duplicate and fitted with steam coils for heating the oil, gage glasses to show the amount of water in the bottom of the tanks, and connections for the oil pumps and for pumps to draw off the water settled out from the oil.

OIL BURNING

96 The importance of proper furnace arrangements with means of controlling and directing the supply of air and fuel has been emphasized in previous discussions. In the case of marine installations it is not always possible to secure the best furnace arrangement. Nearly all the steamers in commission today are equipped with boilers of the internally-fired type. With the short cylindrical furnaces of comparatively small diameter used on these boilers, it is very difficult to secure the highest possible efficiency when burning oil. They are well adapted for the burning of coal.

97 For the burning of oil it is well known that an ample combustion space is needed. With a large combustion space, greater time is available and there is more opportunity for the oil particles to take up their requisite supply of air for combustion. Further, it is important, as has been pointed out, that the direction of the incoming air current should be such as to cause an intimate mixture of the air supply and oil particles. With the short cylindrical furnace these conditions are difficult of attainment. The air and fuel are admitted in sensibly parallel paths. The time during which fuel and air are in the furnace is very short. In consequence, complete combustion is difficult and is always delayed. With water-tube boilers, the furnace conditions are superior, and higher efficiencies have been shown.

98 In considering the installation of a fuel oil equipment, the subject is naturally divided into two parts, the first relating to the storage and handling of the fuel, and the second relating to arrangements for its combustion. Under the first, the safety of the ship and those on board her is the first consideration, and after this come convenience in handling fuel and accessibility of all the important parts; under the second, would be considered the system for burning oil, type of burners, and furnace arrangement.

ATOMIZATION

99 Three systems of atomization are in use in marine installations, namely, steam, air, and mechanical atomization. Of these, by far the greater number of installations in use on the Pacific coast are of the second order.

100 The use of steam for atomization is confined to vessels plying in inland waters, or on very short runs. Steam atomization is not suitable for vessels making voyages of any length because of the large amounts of fresh water necessary for boiler feed to make up the loss due to the steam used for atomizing. This feed water must be carried in tanks, thereby reducing the cargo capacity of the ship, or else made up by the use of evaporators, a very inefficient, expensive arrangement.

101 In air atomization the air is used at pressures of from $1\frac{1}{2}$ to 60 lb. per sq. in., depending on the burner. By far the larger number of oil-burning outfits utilize pressures in the neighborhood of 20 lb. per sq. in., the air being supplied by a steam-driven compressor, or in the case of low pressures, a rotary blower.

102 The third system, mechanical atomization, quite generally known as the "Koerting" or "Meyer" system, although extensively used in Europe, has not yet been adopted to any extent on the Pacific. The atomization is effected by expelling the oil through a small orifice partly closed by a plug, on which is formed a spiral thread. The edges of the orifice are sharp and the spiral thread imparts to the stream of oil a rapid, whirling motion, causing the oil to break up into fine drops which leave the nozzle in a cone of atomized oil upon which the entering air currents impinge.

103 As has been said earlier in the discussion, few data are available showing the efficiency of marine oil installations. The amount of steam required for atomization will range from 2 per cent to 8 or 9 per cent, depending on the type of burner and the intelligence with which it is operated.

104 For air atomization and with air pressures of from 20 to 30 lb. per sq. in., from 6 to 10 cu. ft. of air per minute per pound of oil burned will be required. For air atomization with low pressures, such as can be produced by a rotary blower, of which the Lassoe-Lovekin system as fitted to the steamships of the American Hawaiian Steamship Company is an example, the amount of air required for atomization is not known. The air pressure used is $1\frac{1}{4}$ lb., and all the air is heated by the Howden system. The oil is heated to 175 deg. fahr.

105 A few installations of the third, or mechanical system, have been made on the coast, but no information is available as to the efficiency obtained. In the opinion of the writer, the mechanical system has not received the attention which it deserves from our local engineers. It should be efficient and its simplicity is certainly a recommendation. I am informed by the agent for the Koerting company that the oil may be handled by the ordinary pumps installed for that purpose, with other systems, but that an additional heater is necessary as the temperature of oil at the burner should be from 240 to 260 deg. It is further stated that as long as the pressure of oil at the burner tip is maintained at more than 40 lb. per sq. in., there will be no carbonization in the heating and pipe system, nor in the burner. It is said that 100 lb. per sq. in. at the burner is the most desirable pressure for this system. The makers state that to operate the pumps and supply the heat to the oil necessary with this system takes from $\frac{3}{4}$ to 1 per cent of the steam evaporated.

106 Some large tank steamers fitted with the mechanical system are said to operate very satisfactorily. The results obtained show that a horsepower is developed for from 1.09 to 1.37 lb. of oil per i.h.p-hr. for all purposes. These vessels develop about 1900 h.p.

PRODUCER GAS FROM CRUDE OIL

By E. C. Jones, San Francisco, Cal.
Member of the Society

107 The subject of producer gas from crude petroleum or its products is not enough crystallized to enable the economy to be determined exactly. California, with its immense deposits of petroleum, is the natural and logical field for the exploitation and industrial use of oil producer gas. It is to be deplored that such an important subject was first considered by men not conversant with the manufacture of oil gas, and in casting about for apparatus to make producer gas from oil they naturally gravitated to the old familiar methods of retorting the oil, and any improvements that grew out of these methods seem to have retained the objectionable features of the retort system. Briefly stated, these objections consist of shutdowns for the purpose of removing coke and frequently for burning out accumulated soot and lamp black. A typical analysis of gas made in this way is: CO_2, 4.5; CO, 7.4; O_2, 0.4; CH_4, 12.0; H_2, 3.1; N_2, 71.9; B.t.u. per cu. ft., 172; claimed thermal efficiency, 39 to 62 per cent; operating thermal efficiency, 55 per cent.

108 This gas has been applied to the operation of small gas-engine units up to and including 100 h.p. Owing to the abundance of petroleum in California, it has superseded all crude material in the manufacture of illuminating gas. To attain its present degree of perfection, elaborate experiments were performed for the purpose of changing the chemical and physical condition of the gas to best adapt it to modern domestic and industrial gas appliances.

109 The first oil gas manufactured on a large scale in California had the following analysis:

	Per Cent
Heavy hydrocarbons	6.2
Marsh gas	25.6
Hydrogen	62.4
Carbonic oxide	3.0
Carbonic acid gas	0.2
Oxygen	0.4
Residual nitrogen	2.2
	100.00
Specific gravity	0.303

110 By improvements in apparatus and refinements of operation the hydrogen content of the gas has been reduced to less than 40 per cent; the marsh gas has been increased to 34 per cent; the carbonic oxide has been increased to 9 per cent; the specific gravity to 0.485, and the B.t.u. from 624 to 680 per cu. ft. The oil-gas generators used at present for manufacturing illuminating gas are so elastic in their operation that any of them can be immediately adapted to the manufacture of producer gas from oil. The chemical composition of the gas and its heating value depend only on the manipulation of the generator.

111 The writer has carried on a series of experiments with oil producer gas, using a large generating unit and the only change in equipment was the use of compressed air at from 35 to 40 lb. pressure for the injection of oil and to assist in the partial combustion of the oil. During these experiments producer gas was made having a thermal value as low as 103 B.t.u. per cu. ft., and as high as 482 B.t.u. per cu. ft. Unfortunately no ready means was at hand for measuring the quantity of gas and the amount of oil used to produce 1000 cu. ft. A typical analysis of this gas is as follows:

	Per Cent
Carbonic acid	4
Heavy hydrocarbon	2 or less
Oxygen	1
Carbonic oxide	10
Hydrogen	5
Marsh gas	8
Nitrogen	70
	100

112 This gas has a calorific value of 160 B.t.u. per cu. ft. To use this gas successfully in gas engines it is necessary that it shall be thoroughly cleansed by efficient scrubbing, and that it shall be uniform in calorific value and chemical constituents. This last can be readily accomplished in the operation of oil-gas generators, used as producers, by careful measurement of the oil used, and of the air supplied for its partial combustion, and by the maintenance of a fairly constant temperature in the generator. This can be done, as in oil-gas manufacture, by a determination of the necessary temperature by the observation of color in the checker brick and the maintenance of this temperature by frequent observations through sight cocks by the gas maker.

113 Making producer gas from oil in the ordinary oil-gas generator has many advantages over any special process. The gas can be made in very large quantities and the amount made can be easily regulated to the needs. The operation is continuous and without interruptions for cleaning. This is essential in the manufacture of producer gas for power purposes. In any other known process the interruptions are not at stated intervals, but occur when the producer refuses to work, owing to the clogging of its parts by coke or lamp black. Oil-gas generators have no easily destructible parts as the lining and checker brick are constructed with a view to resisting high temperatures and although a much higher temperature is desirable in making producer gas than that employed in making oil gas, the checker brick is not seriously affected by the high temperature. In the decomposition of oil, in the presence of air, there is a complete disposition of all the gas making constituents of the oil, so that producer gas can be made without a by-product of any kind. Any accumulation of carbon in the generator may be removed by adjusting the temperature and quantity of air supplied. This method of making gas requires a small gas holder for momentary storage, and the process

as at present understood could not be used as a suction gas producer. Producer gas made from oil and containing a small percentage of hydrogen possesses advantages over illuminating oil gas, inasmuch as it can be subjected to higher compression in gas engine cylinders, and with a gas of uniform analysis, uniform piston speed can be obtained.

114 A thought upon the possibilities of oil producer gas leads to a comparison of the modern steam turbine, having a thermal efficiency of from 12 to 15 per cent, with an internal-combustion engine having a thermal efficiency of from 24 to 30 per cent.

DISCUSSION ON FUEL OIL

(Published in Condensed Form)

CONTRIBUTED DISCUSSION

W. H. Frost.[1] The subject of making producer gas from oil first appealed to me commercially, as it would mean a fuel economy two to three times better than with the average steam plant, or would enable crude oil to be substituted for an equal volume of distillate or gasolene in the distillate engines.

I started out not so much to design a new method of making gas as to produce a new power system in which the relation of producer to engine and vice versa must be the first consideration. The question was how to do this. Certainly not with any of the so-called crude-oil generators then on the market, which simply provided a crude method of distillation, sending over indigestible compounds to the engine, and wasting most of the oil as a by-product. With a refined product providing a suitable vapor, it was cheaper and less troublesome to employ the distillate direct in the cylinder.

No successful method of producing a suitable power gas from crude oil was known and as a practical gas engine builder and distributor, I knew the following were necessary to accomplish this:

a To produce the gas continuously in the quantity required by the engine, dispensing with storage.

b The gas to contain the maximum of carbon monoxide and the minimum of hydrogen, to obtain highest thermal efficiency and best regulation of engine.

c Gas to be practically even in quality to prevent shutdowns.

d Gas to be clean, as very minute particles of carbon accumulate and foul engine valves, necessitating shutdowns and cleaning.

e Apparatus to occupy relatively small space.

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[1] Los Angeles, Cal.

Presented at the San Francisco meeting, March 1911, of The American Society of Mechanical Engineers. All discussion is subject to revision.

f Operation to be simple, readily understood by ordinary attendant and requiring minimum of attention.

g To dispense with offensive fumes and by-products.

h To reduce the necessary elements to the minimum.

Oil carries carbon, and the oxygen of the atmosphere is free for the taking everywhere, and these two elements are the only ones necessary. Many forms of apparatus may be used, the most satisfactory seeming to be a simple open chamber into which the oil is sprayed by compressed air and open to the atmosphere through means capable of regulation. Suction is produced by the engine, or any form of suitable exhauster which keeps the interior of the producer at or below atmospheric pressure. The oxygen in the air flowing into the producer and used in spraying the oil unites with a certain portion of the oil to produce combustion and a high temperature. In this high temperature zone the unburnt oil is decomposed into its gaseous elements and free carbon. The carbon dioxide formed by the combustion evidently selects carbon from the products of the decomposition of the oil to form carbon monoxide.

An average analysis of the gas gives:

Carbon dioxide	6.0
Oxygen	1.0
Illuminants	2.2
Carbon monoxide	13.6
Hydrogen	6.2
Methane	3.3
Nitrogen	67.7
	100.0
B.t.u. per cu. ft.	141.0

Gas can be made as lean as wanted, or to contain considerably over 200 B.t.u.

Regulation of the free air openings and of the oil controls the quality and also the volume of gas and can be automatically governed by the engine. A test flame kept burning is an indication to the attendant of the quality of the gas. Sight holes also show the internal condition of the producer.

During experiments and tests of several years' duration, it was found that engines operated most steadily and evenly and the apparatus required the least attention, when the temperature of the producer was sufficiently high to break up completely the tarry vapors into gas and carbon.

The most difficult task of all was to separate the fine, almost microscopic, particles of carbon from the gas, so that it would be perfectly clean and suited to any gas engine. Eventually, a centrifugal scrubber of simple design was devised, which absolutely cleans the gas, so much so that fine white muslin held for one or two minutes over a 1-in. outlet with gas under 2-in. water pressure, sufficient to make a very long flame, shows no stain whatever and if kept there for 2 hours shows only a slight discoloration. The scrubber doing this is about 4 ft. in diameter by 5 ft. long, and cleans about 35,000 cu. ft. of gas per hour.

The fine dry carbon, free from tar, is collected from the wash water by any convenient means. In a plant of 500 h.p. it is not sufficient in quantity to require any special separating device, but is collected in a skimming tank in the usual manner. This fine clean carbon has many valuable uses, particularly in paint for metal or wood.

The economy, of course, varies with the engine, but actual runs on plants of 100 to 500 h.p. show that a guarantee of $1\frac{1}{8}$ lb. of oil per b.h.p. is perfectly safe.

As to sizes of producers, with a circular chamber less than 18 in. in diameter by 4 ft. long, or about 7 cu. ft. capacity, I have made the gas required to operate a 150-h.p. engine full load, but prefer larger capacity, at least for the present.

Mr. Jones in his paper on producer gas from crude oil states: "The operation is continuous, and without interruptions for cleaning. This is essential in the manufacture of producer gas for power purposes." Quoting again, "Any accumulation of carbon in the generator may be removed by adjusting the temperature and quantity of air supplied." This indicates that there is a necessity for cleaning but that a change in proportion of air, with consequent change in temperature (probably more air raises temperature), causes the accumulated deposits to be consumed. My experience has been that any change in temperature, or proportion of elements, changes the quality of the gas and causes shutdown of the engine. The change mentioned would probably make the gas leaner.

The only way to avoid serious engine troubles would be to provide sufficient storage so that the changes of gas values would be very slow and gradual and even then the load must never be greater than the leanest gas will carry, and the engine requires close attention and skilful handling. Even if the leanest gas can be kept up to 160 B.t.u., it will require 37,500 cu. ft. per hr. for a 500 h.p.

load (12,000 B.t.u. per b.h.p), making an enormous storage capacity necessary to anywhere near the average of the quality of the gas.

The statement of the necessity of changes also shows that this is not a continuous process producing a uniform gas, but one producing a continuous supply of gases of varying values, whereas a continuous supply of a practically uniform gas is absolutely essential to any engine I have operated.

Quoting again from Mr. Jones' paper, "Making producer gas from oil in the ordinary gas generator has many advantages over any special process." What are the advantages? What power plant would want such an equipment as is required for illuminating gas making? Bulky retorts, large scrubbers and filters for the great volume of gas required, and big gas holders, are necessary for all pressure systems and also to average the quality of gas.

The paper indicates that certain results have been accomplished, but lacks the statement that gas engines are successfully operating with this gas. By the process there presented there is evidently a by-product of lamp black or tar or both which must be separated by washing and filtering to fit it for the engine. Evidently the process does not produce an even and uniform gas continuously and evidently Mr. Jones relies upon the gas holder for averaging the gas, as with illuminating gas; but this is expensive, and impracticable with a power plant of average size and an impossibility within the fire limits of cities.

C. R. Weymouth. If we assume that the range of fuel oil ordinarily varies between the limits of 12 and 18 deg. Baumé, we find, in accordance with Table 2 of Professor LeConte's paper an increase of 2.18 per cent in the total heat units per barrel, in favor of the heavier oil. So long as the barrel is the unit in the purchase of oil, power plant operators cannot ignore this comparison.

Since the reading of these papers the writer has endeavored to collect data in an attempt to establish a relation between the specific gravity of California crude oil, Baumé scale, and the percentage of hydrogen shown by its ultimate analysis in order to compute a table showing the available heat per pound and per barrel of crude oil of varying gravities, correcting for loss due to latent heat of steam formed by the combustion of hydrogen. Curve No. 1 shows the hydrogen content for a number of oils of different gravities, Edmond O'Neill, professor of chemistry at the University of California, having furnished a large part of the data.

It is found that there is no exact relationship between the specific gravity of crude oil and its hydrogen content, although there is a general tendency toward an increase in hydrogen content, with the lighter oils.

Examination of the ultimate analysis and calorimeter tests of a number of California crude oils indicates the rather startling fact that it is possible in oils having practically the same total quantity of inert constituents, to have a variation in both hydrogen and carbon contents with practically no variation in the calorific value of the oil.

The inevitable conclusions that the calorific value of crude oil does not correspond to the heat of combustion of its elemental constituents, and that accepted formulae for calculating the total heat of fuels are not applicable to California crude oils, are borne out by the fact that the calculated calorific value was, in one instance, 8.7 per cent greater than obtained from a calorimeter test. This apparent anomaly is no doubt explained by the fact that crude oil is an admixture of various hydrocarbons, in the formation of which the heat required is not available in the further combustion as crude oil.

From Table 2 the writer calculated the variation in hydrogen due to variation in heat units, according to Favre and Silberman's formulae, the result being an increase of 1.263 per cent hydrogen for 10 deg. increase Baumé. From the foregoing it is evident that this relationship cannot be regarded as more than an approximation. As a matter of interest, a line has been drawn on the accompanying plate having its slope in accordance with this, and located as an average with respect to the plotted points. The writer considers that more points should be plotted to warrant even an average line. It is evident, however, from the points plotted, that the true average will have less slope than the line indicated. On the basis of the line indicated, and correcting for latent heat of steam only, the available heat per barrel of oil is 2.32 per cent greater for 12 than for 18 deg. Baumé oil. If further corrections be made for the added stack losses at a temperature of 400 deg. fahr. due to the greater air required for combustion, then 12 deg. Baumé oil has an advantage over 18 deg. Baumé oil of 2.37 per cent.

It should be evident from the wide scattering of the hydrogen points that the comparison of any two oils under consideration should be made with respect to their individual analyses, and not with respect to the average line mentioned. For example, from the plotted points a hydrogen variation of 1.6 per cent is noticeable with practically no variation on the Baumé scale, corresponding to which the stated increase of hydrogen involves a commercial loss, due to its lower available heat, and increased chimney losses of approximately 1 per cent. Taking into consideration this loss and the greater total heat units of heavy oils, the extreme variation in the commercial value of anhydrous crude oils, between the limits of 12 and 18 deg. Baumé appears to be not greater than 3 per cent.

As a result of all the tests made by Chas. C. Moore & Company, Engineers, and the Babcock & Wilcox Company, with California crude oils, it is not apparent that the above conclusions will be materially modified by a consideration of the atomizing agent, when oils are heated to the proper temperature before firing.

It should be noted that Table 1 is intended to represent a general average, the line being drawn through plotted points considerably scattered. Calorimeter determinations will still be necessary as the specific gravity of an oil is not an accurate index of its calorific value.

Mr. Dunn has fairly represented current practice in the design of chimneys for oil fired boilers at sea level, for moderate sized plants.

About eight years ago, the writer established, for Chas. C. Moore & Company, a rule for oil-burning chimneys, as set forth in Mr. Dunn's paper, and while such a basis for the selection of chimneys has kept them out of difficulties, recent investigations indicate the desirability of a radical departure from this rule in certain special instances.

For the benefit of those who contemplate using Kent's table of chimney capacities as a basis of selection of chimneys for oil-burning plants, the writer would state that Mr. Dunn's explanation of the reasons for adducing the rule stated, is hardly correct. The weight of chimney gases per boiler horsepower, when burning coal, is not twice that when burning oil. It is possible to use chimneys of smaller area for oil burning than for coal burning, by reason of the much lower draft required for the former, permitting higher velocities in the chimney, and a greater percentage of draft loss in the chimney proper. Mr. Kent probably never intended the widespread usage accorded his table of chimney capacities, and before adopting this for too general usage, engineers would do well to inquire the basis of development and the significance of the figures given.

According to Kent's table, a chimney 48 in. in diameter by 100 ft. in height, is rated at 348 commercial h.p. According to Mr. Dunn's paper, this chimney would develop double that amount, or practically 700 b.h.p. The questions arise, should this chimney be connected to boilers aggregating 700 h.p. based on the normal rating, will it merely carry boilers when operating at rating, or does it provide a margin for overload, and if so, to what extent; and were it desirable, in such a plant, to operate both boilers temporarily at 100 per cent overload, developing 1400 b.h.p., would it be necessary to install a chimney of double the sectional area? The writer no longer uses Kent's table for selecting chimneys for oil-fired boilers, and it is not possible to obtain correct ratings for oil chimneys by applying a fixed ratio to the capacity set forth in it.

With economical firing, and with properly designed furnaces, the draft in the third pass, required to burn oil in a Babcock & Wilcox boiler of, say 250-h.p. rating, is about 0.1 in. If this boiler be connected to a chimney 100 ft. in height, giving a working draft at the base of the chimney of, say 0.5 in., it is evident that this surplus draft is capable of flooding the boiler with an excess of air, if the draft be improperly regulated. Such an operation could easily result in such a large excess of air for combustion as to require the burning of 10 per cent excess oil, merely to heat to the stack temperature the air so admitted.

If for the given single boiler the chimney height be reduced approximately to 35 ft., the boiler outlet and breaching being of ample area, and the stack being direct connected to the boiler, the chimney would then produce a maximum draft practically equivalent to that required for the operation of the boiler at rating; and with boiler damper and ashpit doors wide open, it would be impossible for the most careless firemen to flood the furnaces with any material excess of air. The writer does not recommend that all chimney heights be reduced to 35 ft., but this illustration serves to indicate an extent of safeguarding the fuel economy of the boiler room, not possible by any other simple means.

In an office building in San Francisco, it was found necessary, by reason of the height of the building, to install a chimney extending more than 200 ft. above the boiler room floor line. On one occasion the analysis of flue gases, in connection with this chimney, indicated 200 per cent air over actual requirements, and a certain fuel loss, as compared with economical firing, of at least 20 per cent. While, in this instance, it was impossible to reduce the height of the chimney, the diameter could have been decreased to such an extent, that the available draft at the base would have been reduced by the chimney friction to an amount more nearly in keeping with the boiler requirements.

As illustrating the overloading and abuse of boilers possible with excessive drafts, the writer has in mind a Stirling boiler having a connected chimney of generous diameter, 80 ft. in height. The damper lever had been disconnected, and the boiler fired with both rear damper and ash doors wide open. The fireman was instructed in the regulation of dampers and ash doors, but failed to observe these instructions. Subsequent tests indicated overloads of several hours' duration, of 85 per cent, and momentary overloads of even greater extent. There were other boilers in service, having less draft power, which were not overloaded to this extent. In the plant in question, all boilers should have been operated practically at rating on a nearly uniform factory load. Obviously the overloading of this particular boiler led to a considerable fuel loss. To obviate these difficulties the writer has recently recommended a 40-ft. reduction in the height of this chimney. A greater reduction would be possible from the boiler standpoint, but is in this instance limited by height of building.

When operating boilers under variable load, a careless fireman is liable to discover that the steam gage reads 5 or 6 lb. low and rapidly falling. Through habit, he has learned that this loss can be overcome by a few moments of heavy firing. During such periods, the boiler is frequently fired at from 200 per cent to 300 per cent rating and boiler tube renewals are many times chargeable to this cause, not to mention the resulting excessive oil consumption. While a certain excess draft is necessary for proper regulation of boiler plants on variable load, it is self-evident that it can lead only to severe abuse of boilers in the hands of ordinary firemen.

Prior to the burning of oil in Pacific coast plants, chimneys were proportioned for coal-burning practice, and in many instances the subsequent failure to obtain favorable economy with oil fuel in everyday work was attributable to tall chimneys. In a number of those stations it was later found possible to increase largely the number of boilers connected to one chimney, the station economy was improved without apparent effort of the firemen, since the increased volume of gases passing through the flues and chimney reduced the draft available at the boiler outlet, and at once limited the extent of flooding the furnaces with excess air, formerly possible with an excessive draft.

It has been found by experiment that the draft necessary for the combustion of oil varies largely with the economy of firing, and in one series of tests, operating the same boiler at approximately rated capacity, the draft varied from less than 0.1 in. with economical firing, to nearly 0.5 in. with a large excess of air; also that the draft necessary to burn oil increases rapidly with the rate of overload on boiler.

It therefore becomes necessary, in the selection of chimneys for a given plant, to decide both the maximum capacity to which it is desirable momentarily to force boilers, and the excess air supply over the most favorable firing conditions, to be regarded as the limit of safety in everyday practice. The installation of fuel economizers, excessive breeching resistances, etc., will also influence the final result. These considerations determine the draft necessary at the base of chimney. There is a minimum height of chimney which will produce the desired draft, and should it become necessary to increase the chimney height over and above the necessary minimum, the diameter of the chimney, for economical firing, should be modified to absorb by chimney and breeching friction the excess draft thus produced. The provision for a later increase of boilers on a given chimney will of course modify these conditions.

There are many factory, pumping and heating plants where the load on the boilers in service is practically uniform and rarely exceeds rating. In certain of these plants, not operated by skilful firemen, it would be possible, building conditions permitting, to reduce materially the chimney height with an increase in fuel economy.

In reply to a query by Mr. Hunt, by controlling the firing of boilers by variation of oil pressure from a central point, all burners being connected to a common oil main, it is possible to indicate the rate of load on the individual boilers by pressure gages connected to the oil-burner branch line. At the Redondo plant we controlled the firing of boilers from a central point, the individual oil-burner regulating valves being wide open or nearly so. The pressure gage read about 20 lb. when the boilers were fired at rating, about 10 lb. at half load, and about 30 lb. when at 50 per cent overload. When used in this manner the pressure gage forms a reliable index for gaging the load on boilers, at least for the purpose of the firemen, and it is about as cheap an instrument as can be secured for the work.

W. F. Durand. In connection with Mr. Dunn's paper on chimney capacities, the accompanying formulae may be submitted as representing conservative practice under what may be denominated approximately normal operating conditions. The factors which enter into the problem of chimney draft and capacity are so numerous, their relations so obscure and values so difficult of numerical determination, that of necessity all chimney formulae are empirical, that is, they are simply practice expressed in algebraic form. The literature of engineering abounds in chimney formulae, but inasmuch as most of them relate to coal-burning practice, I have ventured to add one more to the list, intended to refer strictly to oil-burning practice.

While, as noted, all chimney formulae are empirical in character, yet they may to some extent be made rational in form and the more nearly such a condition is realized the better will the formula take care of variations in the operative conditions, outside the immediate range from which the empirical factors are drawn.

The general character of a chimney formula on rational lines may be readily developed, as follows: The function of draft involves the pushing of air into the furnace and the pushing of the gases of combustion through the tube spaces and then up the stack to the outer air. This involves the work of giving kinetic energy to a body of air and gas and of moving it against a resistance. In general, such work will depend on the quantity of gas moved and on the square of the velocity. This work must be supplied by the draft head or difference of pressure between the external air and minimum pressure within the boiler, and per pound the work will be measured by the difference of pressure in pounds per square foot multiplied by the volume of one pound of gas in cubic feet. We have thus in general the relation:

$$u^2 \sim VP$$

where

u = velocity
V = vol. per lb.
P = draft head measured in lb. per sq. ft.

Again, let

B = boiler h.p.
w = lb. of gas per b.h.p.
A = area of chimney

Then

$$BwV = \text{Total volume of gas} = Au$$

But $u \sim \sqrt{VP}$, and P the draft head will depend in general on the height of the stack and on the stack temperature. According to the simple theory of stack draft, such head is measured by the difference in weight between a column of normal air and a column of hot gas, each of the height of the chimney.

In any event, we may put

$$P \sim hx$$

where

h = height of chimney
x = a factor or term depending on the temperature

We have then

$$u \sim \sqrt{Vhx}$$

and hence

$$A\sqrt{Vhx} \sim BwV$$

whence

$$A\sqrt{h} \sim Bw\sqrt{\frac{V}{x}}$$

In words, the product of the area by the square root of the height should follow closely the product of the number of pounds of gas by the square root of the volume per pound and divided by the square root of the function x.

But the volume of 1 lb. of gas V varies directly as the absolute temperature. This of course varies widely between the furnace and the top of the stack. The temperature at the base of the stack is usually taken, however, as primarily related to the value of the draft function x, and for convenience we may use the same temperature as related in a general way to the value of V. Also w, the pounds of gas per boiler horsepower, will vary inversely as the boiler efficiency. Let e denote the efficiency. Then we may write

$$A\sqrt{h} = \frac{B}{Qe}\sqrt{\frac{Ts}{x}}$$

where Q is the general constant or factor.

The function x takes the form $\frac{A}{Ta} - \frac{B}{Ts}$, where A and B are constants and Ta and Ts are absolute temperatures of the air and of the stack. Where draft head d is expressed in inches of water and the height of the chimney in feet, this takes the form

$$d = h\left(\frac{7.6}{Ta} - \frac{7.9}{Ts}\right)$$

If 80 deg. fahr. is taken as a fair upper temperature of the air, this reduces to

$$d = h\left(0.1407 - \frac{7.9}{Ts}\right)$$

The entire $\sqrt{\frac{Ts}{x}}$ is therefore a function of the temperature and its value for a range of values of Ts is given in Table 8.

It now remains only to find a value for the numerical constant Q. This has been done by using the results of practice and thus checking the formula against the indications of experience.

TABLE 8 VALUE OF TEMPERATURE FUNCTIONS

t	y	t	y
400	4.19	560	4.02
420	4.16	580	4.01
440	4.12	600	4.00
460	4.10	620	4.00
480	4.07	640	4.00
500	4.05	660	4.00
520	4.04	680	4.00
540	4.03	700	4.00

In this manner, we find as follows:

$$(A - a)\ \sqrt{h} = \frac{By}{Qe}$$

where

A = area of chimney in sq. ft.
a = small constant area as below
h = height in ft.
B = b.h.p. actually developed, which equals number of lb. of total evaporation per hour reduced to conditions from and at 212 deg., divided by 34.5
e = boiler efficiency
y = temperature factor from the table
Q = coefficient

values of a and Q are as follows: For large chimneys or from 300 b.h.p. up

$$a = 2.5$$
$$Q = 54$$

For small chimneys or from 500 h.p. down

$$a = 0.6$$
$$Q = 40$$

In choosing the values of the constant Q the following special conditions are assumed:

Heat value of oil fuel	about 18,500 B.t.u.
Temperature of external air	20 deg. fahr.
Excess of air in furnace	about 100 per cent

Boilers working at rate of output not greatly exceeding rated load.

The particular numerical factors in the formula are perhaps not so important. I dare say further investigation, undoubtedly the results of Mr. Weymouth's data, might change the numerical factors. I believe, however, that the form of the formula may possibly be of some aid in passing from one set of conditions to another, or interpolating between various sets of conditions; and that is about all any engineering formula can hope to do.

In connection with the paper by Mr. Hunt on Atomization, I have been interested in estimating the work equivalent of this process. The nozzle of a burner is a more or less effective device for transforming energy of steam into jet energy, exactly in the same manner as does the nozzle of a steam turbine. The atomization of the oil and its projection at high velocity into the furnace involve the expenditure of work, and this work must be derived from the steam by way of the nozzle.

One-half lb. of steam per lb. of oil is perhaps a fairly representative figure for the amount of steam required. This amount of steam used with any reasonable nozzle efficiency and under the conditions of say 90 lb. initial pressure absolute and 15 terminal, should develop from 35,000 to 40,000 ft. lb. of energy, thus expended in work on the oil. This figure is impressive. It is probable that due to wire drawing and inefficiency in the nozzle the amount of work actually utilized is less than this figure. In any event, however, the price paid for the preparation and introduction of the oil into the furnace is a very heavy one, and the question not unnaturally arises as to whether or not this can be the ultimate method. May not some method be developed, mechanical or otherwise, which shall enable us to do the necessary amount of work on the oil without the heavy expenditure involved in the present systems of steam or air atomization. Mechanical atomization seems to present some possibilities and it may be that the future development may lie along this path. In any event, I feel that as engineers we should entertain a feeling of profound discontent with our present methods of preparing and introducing the oil into the furnace, and that we should not rest until either some less costly method is developed, or every possible method and expedient has been given a thorough trial.

Guy L. Bayley.[1] In order to get some information as to the efficiency of the furnaces in the station of the Municipal Light & Power

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[1] Mgr., Municipal Light & Power Co., San Francisco, Cal.

Company plant, on Stevenson Street, we installed an Orsat apparatus in the fireroom. The four boilers are of Stirling make, and the samples were taken about a foot below the damper. The sampling tube used in each was a piece of $\frac{3}{8}$-in. iron pipe, open at the end. Small lead pipes from each furnace were run to a header with a valve in each, so that a sample could readily be taken from any of the furnaces. A small water ejector was connected to the header to insure drawing over a fresh quantity of flue gas before a sample was taken. We experienced trouble with the lead piping from pin-hole air leaks, and from the piping sagging and forming pockets, which trapped water from the products of combustion and prevented a flow of flue gas. These troubles were overcome by the use of $\frac{1}{4}$-in. iron pipe.

The Orsat determinations were of great value at the start in educating the firemen as to the amount of air required. All of our men were experienced in the burning of fuel oil, but they were firing with from 80 to over 150 per cent excess air. By shutting down on the draft and making frequent determinations with the Orsat apparatus until a high per cent of CO_2 was obtained, the firemen were taught how a fire should appear with the minimum amount of air for complete combustion. We were unable to get much better than 12 per cent CO_2, as above this point the fire was liable to produce smoke, which would not long be tolerated in the neighborhood of our plant.

Although we had no direct means of measuring the economy due to better firing, an increase in kw-hr. per bbl. of oil followed at once. The second month we had the Orsat installed, we showed an increase of 19.3 per cent in the kw-hr. per bbl. of oil obtained the month before installing the Orsat. During this period the load factor on the turbine increased from 43 to 53.5 per cent, which would account for some of the increase in economy, but hardly for the amount obtained.

The Orsat apparatus is not a suitable instrument for constant fireroom use, as the rubber connections rapidly deteriorate and the glass parts get broken. It is well worth its cost, however, as it will awaken and maintain in the firemen a lively interest in the subject of combustion, which is sure to result in better firing. In order that the firemen may appreciate the importance of maintaining a high percentage of CO_2, we have posted in the fireroom two curves, one of which gives the relation between percentage of CO_2 and of excess air; the other, the relations between the percentage of excess air, flue temperature and calculated boiler efficiency.

To measure the oil in our fuel tanks, we run to each a $\frac{1}{4}$-in. brass pipe, which goes through the top of the tank to a point close to the bottom. To each pipe, at a convenient point in the engine room, a U-tube containing mercury is attached. Each pipe is connected to the compressed air system of the plant. To read the height of oil in a tank, the compressed air is turned into the pipe until it blows out the oil which may be standing in the vertical section leading down to the bottom of the tank. The air is then throttled down so that only a small amount escapes through the oil, and a reading taken of the difference in level of the mercury in the U-tube. A scale alongside the U-tube can be calibrated by means of known quantities of oil in the tank, so as to read direct the number of barrels contained in the tank at any time. In a tank 13 ft. deep and holding 110 bbl., we can read within a barrel of the true amount in the tank. By inclining the tubes so as to get a longer range of movement of the mercury, greater accuracy can be obtained. Should the gravity of the oil change from that used when calibrating the U-tubes, the readings must be corrected for the difference in gravity.

Thos. Morrin. The use of crude oil as fuel has been developed along the lines of unlimited extravagance in the vaporizing process. Until recently steam jets have been used in land plants at full boiler pressure for vaporizing oil at the burner tip, because of its convenience and low cost of application. At the same time it is perhaps the most expensive method for accomplishing this object. I believe that improvement in these conditions can be brought about only by a burner mechanism that will require air only at an extremely low pressure which may be furnished at a minimum cost so that its most extravagant use cannot go beyond a certain fixed range.

In regard to Mr. Hunt's statement that the form of the burner is of minor importance I am convinced that it has much to do with preparing the oil for satisfactory combustion inasmuch as it is necessary to vaporize the oil or work it up into minute atoms.

I have in mind mechanical burners of the turbine fanwheel type rotating at a high speed and delivering the oil from the periphery of the burner at a velocity of approximately 7100 ft. per min., equal to an air pressure of approximately $1\frac{1}{2}$ oz. per sq. in.

In tests of the quantity of oil and the percentage of power used to burn a fixed quantity it was noted that the energy expended was less than 1 per cent. In fact, the figures showed an actual consumption of energy amounting to but $\frac{6}{10}$ of 1 per cent of the actual heat results of the oil burned.

I refer to this scheme of vaporizing oil because I am sure that oil will be used more and more for fuel purposes if we convince the consumer that it is unnecessary to install a steam burner or an elaborate mechanical equipment. A simple centrifugal blower and a rotary gear pump driven by one electric motor that any unskilled person may use and operate is a possible equipment.

The form of furnace is also important. The hearth of the furnaces should be of good fire-resisting material, of high radiating efficiency, and thin, with air inlets well diffused over the surface, and while it is not necessary to heat the air for the most economical results, oil can be burned in the jet process with much less noise with heated than with cold air. This system for vaporizing oil is just as applicable to service on board ship as to the most remote fruit dryer, hop kiln, or malt house, where it would be necessary to install only a small motor and volume blower with the necessary oil pump, within the prescribed limits of the underwriters. With this method of vaporizing the oil, less energy per pound burned is required than in any other form now in use, and it should receive more attention from engineers and consumers than in the past.

ORAL DISCUSSION

George W. Dickie said that the example given by Mr. Hopps of oil burning on one of the American Hawaiian Steamship Company's ships fitted with Scotch boilers, compared favorably with any examples he could give for water-tube boilers, although Mr. Hopps claimed that the furnace conditions of water-tube boilers are, generally speaking, superior to those of Scotch boilers. The Howden system of furnace combustion and the low-pressure air system may have contributed to the satisfactory result.

Mr. Dickie expressed approval of the mechanical system of atomization, having been an admirer of the Koerting system which he believed needed only careful study and adaptation to the various qualities of oils to make it ideal. So convinced was he that a practical system of this nature was feasible that if he were to design a large marine oil-burning installation he would endeavor to design a modification of the Koerting system that would successfully burn the California oils.

In reference to making producer gas in an ordinary gas generator for use in internal combustion engines, he urged Mr. Jones to make further experiments, suggesting that if a slow-burning gas could be made from oil which would behave behind the engine piston like slow-burning powders behind the projectile of a modern gun, giving a steady push instead of a blow, a remarkable instrument of propulsion would be produced. For two years past he had been interested in a crude oil gas producer known as the Nix-Frost producer by which oil is converted into a fixed gas which is essentially a power gas consisting mainly of carbon monoxide with a small percentage of hydrogen.

In this producer the oil is brought to the burners by any suitable pressure means and compressed air sprays it into the producer, which consists of a steel shell lined with fire brick with a central vertical chamber. A zone of high temperature is formed by partial combustion and through this is drawn the unconsumed carbon, and the gas produced, along with fine particles of carbon, is drawn out of the producer through a suitable scrubber by suction fan or by the engine direct; any particles of carbon are separated and blown away with the waste water. This producer or something like it may yet be made suitable for marine installations.

E. I. Dyer[1] said that the relation of the heat value of oil to its specific gravity was not commonly appreciated either by the average oil producer or the consumer. Lack of knowledge of the truth of the relations exhibited in Professor LeConte's paper, and of the part which hydrogen plays in the lighter oils, in the economics of combustion, together with a blind adherence to the traditional temperature of 160 deg. fahr. for fuel oil, have conspired to create an unwarranted prejudice in favor of light oils for fuel purposes. He thought that there was no insurmountable difficulty in handling and burning heavy crude oils at temperatures to the burner ranging from 240 to 350 deg. fahr. In fact, at one of the plants of his company, 285 deg. fahr. has been the standard temperature for months. Both the producers and consumers of oil would be benefited by further elaboration of the fact that not only do the heavier oils contain more heat units for a dollar, but within reasonable limits, a greater proportion of available heat units than the lighter. A real service to the general public might also be rendered by dispelling the confusion in the conversion of Baumé degrees to true specific gravity.

The relative heating value of oil and coal is of vital importance both to the producer and consumer. The characteristics of coal commonly available in this market and not the ratio as it relates to Pocahontas coal, are of interest on the Pacific Coast. The establishment of an evaporation of 11 lb. from and at 212 deg. per lb. of coal as representing the highest average of a good coal, would mislead every one on the coast who had anything to do with oil. The ratio which has been presented by previous speakers may be true of Eastern conditions, but entirely fails to represent those in the West. A ratio of 15.8 to 11.2 gives oil a superiority over coal by something over 40 per cent, weight for weight. Mr. Hopps has pointed out that in marine practice a vessel equipped with triple expansion engines from 1000 h.p. up, with everything in first-class condition, would consume about $1\frac{1}{4}$ lb. of oil per i.h.p-hr. This is probably a fair average.

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[1] Engineer of Manufacturing Department of the Union Oil Company, San Francisco, Cal.

The speaker had had access some two or three years ago to the records of performances of several steamers running on the coast with average coal for an entire year. One of these vessels averaged 2.1 lb. of coal per i.h.p-hr., and the other 2.5, and both had triple-expansion engines larger than the lower limit of size given by Mr. Hopps. The better record showed about 70 per cent more weight of coal and the poorer 100 per cent more than the $1\frac{1}{4}$ lb. average for oil. He gave these figures in the hope of showing why this subject should not be dismissed without receiving full justice.

With regard to furnace arrangements, he said that both producers and consumers were much indebted for the development of the efficient types of furnaces now in operation. These would be of still greater value if their operation could be made as nearly automatic as possible, or some system developed by which the specialized knowledge available could be taught to the men handling the fires. He also thought furnaces should be more liberally provided with peep-holes, so that all parts of the furnace and the heating surface exposed in it, as well as all parts of the fire, could be seen at all times. These were usually insufficient in number, often incorrectly placed, and in many cases entirely missing. Where present, they were often of a type which could not be operated without a hammer and consequently were never used.

Explosion doors, as often provided, are frequently not tight when inactive and will not close themselves after acting. Sometimes they are so situated that they become overheated, warping to such an extent as to nullify all attempts to regulate properly the air supply. An indicating CO_2 instrument should be a part of the equipment of every boiler furnace in every high-grade installation, as much as a steam gage. Similarly a draft gage reading to hundredths of an inch should also be a part of every standard boiler equipment, if any pretense is to be made of securing economical combustion of oil. More care might be given to the placing of burners to avoid possibility of oil, particularly sulphurous oil, lodging on the tubes. A checkerwork with variable opening operated by a lever from the front, if such a device could be made practicable, would probably be worth while. All dampers ought to be operated from the front and a draft gage maintained at that point.

The stack problem is, of course, intimately associated with that of furnaces. If the correct height were 80 to 100 ft., how could the fact be accounted for that a boiler plant of 600 h.p. capacity with stacks only 51 ft. above the floor line, recently installed by the speaker, developed an average of 170 per cent of rating with peaks running up to 200 per cent on a five-day test? Not only this, but the height is such that the firemen have to be watched to prevent the admission of an excess of air. Moreover, in the same building a recent storm has entirely destroyed a number of stacks on some return tubular boilers down to the roof line, and there is not the slightest difficulty in running these boilers up to capacity with the stacks in this condition. In this case, the height of stacks could not be more than about 25 ft. above the floor. If all the overload capacity consistent with safety could be secured and the firemen still get an excess of air if not watched, manifestly 50-ft. stacks are too high. At another plant of 1200 h.p. in four units, the stacks are 72 ft. high. These are made higher than would be ordinarily necessary on account of the configuration of the surroundings. With these stacks, the boilers can be operated at any reasonable overload and if the fireman is not watched he will get his CO_2 as low as 2 per cent. These stacks are, therefore, too high, except perhaps under conditions which might bring to bear the adverse influence of the winds passing over the surrounding hills. It is manifestly unsafe to generalize on either the height or diameter of stacks without knowing all of the conditions. The draft resistance differs in different types of boilers; the amount of overload desired has an influence on the height and area; the draft resistance in the boiler increases with overload; conditions which obtain at sea-level are not present at altitude; the direction of prevailing winds as regards the situation of the plant with reference to the configuration of the surroundings is of consequence; there is a great difference whether each boiler is equipped with an individual stack, one stack per battery of two, or one stack serving several, with connecting breeching; every turn in a breeching introduces a draft loss: the frictional resistance and the cooling effect of economizers must be taken into consideration; for construction purposes there is an economical ratio of height to diameter; the price of fuel oil is a consideration, etc. So many factors enter into the design and proportions of stacks that the subject is a complicated one, and worthy of more extensive exploitation.

As to the use of compressed air instead of steam for atomizing, a special occasion for using it in place of steam is probably offered by plants where exhaust steam does not exist in sufficient quantities for heating purposes within the limits of temperature obtainable by steam at or near atmospheric pressure. A plant of 2000 b.h.p. located in Seattle and used entirely for a district steam heating system would seem to present a possibility for this practice. Industrial operations involving the use of large quantities of heat at relatively low temperatures, of which there are a number of examples, might also be similarly situated.

J. A. YEATMAN[1] expressed his interest in the production of power from California crude oil by means of gas engines, or producers for gas engines. California oil is not freely vaporized and in order to prepare it so that it might be burned in a gas engine, retorts were first used, heated externally or from the exhaust from an engine. Inasmuch as the oil had a deposit of clay or earthy matter which the oil companies were not extracting, the retort would foul in a short time and become incrusted with carbon and dirt. Gas producers were then taken up something after the lines of the hard and soft coal producers of the East, but it was found that the percentage of hydrogen was so great that they had to reduce the compression. There would then be ignition troubles if the proportions were not correct. Later Mr. Frost developed his producer which the speaker had observed in operation and found to work satisfactorily; but the gas engines operated in connection with it required excessive bore and stroke for a given amount of power, which increased the internal friction. The device, while simple to an engineer, is quite complicated to the average small gas-engine user.

With regard to the oil engine, Mr. Yeatman said the oil companies were now extracting the dirt from the oil by centrifugal separators so that engines would operate without fouling the cylinders, and its use was one of atomization.

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[1] United Iron Works, San Francisco, Cal.

Ordinary carburetors, or most of them, are based on the suction principle, which is not sufficient to atomize the ordinary 10 to 18 deg. gravity oils. Some manufacturers have developed a pressure atomizing mechanism which takes the place of a suction carburetor and considerable success has been had along these lines. Mr. Yeatman had been informed by engineers who had observed tests that with the pressure atomizing apparatus they had been able to produce a horsepower with $\frac{6}{10}$ lb. of California crude oil of 14 deg. gravity, which he thought marked probably the greatest progress toward economical production of power that he had heard of, and indicated lines for progress improvements.

A. M. Hunt, the chairman of the meeting, said that the subject of the direct combustion of the fuel in the gas engine cylinder might profitably form a subject for discussion and referred to the Diesel engine which is used to a very considerable extent abroad, even in units of large size, but had never gained a foothold in California.

G. H. Marx said that in 1904 he visited the laboratories at Munich, and was shown the engine on which Professor Shröder had performed his experiments, by his assistant, who assured him that they had used California crude petroleum in some of their tests, and that the petroleum had worked very satisfactorily, and left no residue in the cylinder.

Howard Stillman spoke of the operation of Diesel engines, relating experiences in the shops of the Southern Pacific Company at Ogden, Utah, and at Tucson, Ariz. He recounted how attempts had been made to operate the engine at Ogden with California crude oil, which were without success because it was frequently stopping and tying up the shop. A lighter distillate was then used which worked very well and was exceedingly economical, but even then, the engine was not reliable. The shop could not be kept going without resorting to the old steam engine. There were records of three weeks at a time when the performance was remarkable and then would come a period of, say two weeks when the Diesel Engine was hung up for repairs and the steam engine had to be used.

At Tucson the engine was maintained longer, covering a period of three years, and the same attempts were made to use the crude oil or a lower gravity oil, but the engine was intermittent in its action. Finally, a Texas oil of lighter gravity than the California oil was adopted and the performance of the engine was fairly good, although it had its difficulties. When it was working it was a splendid machine. One attempt was made to dismantle the steam engine but fortunately this had not been completely done, when its services were required because of trouble with the Diesel motor. The motor was finally abandoned as it was found there was no net economy in operation. It could not be prophesied when it was going to stop and the steam engine was finally put into regular service again. Delays in operation of lineshafting in machine shop during working hours were expensive.

R. W. FENN said that he had been in Chili and had found Diesel engines quite common there and inquired particularly about their operation from engineers in charge of them. They pronounced them ideal, but were using a Peruvian crude oil of 34 deg. gravity.

A. F. L. BELL reported trouble in the operation of a 1000-h.p. Diesel engine installed at the United Verdi Mine. The engine had been bought without giving attention to where the oil was to be obtained and experiments were now being tried with samples of oil and distillate from different parts of the California oil fields. He thought that the California oil must have a carbonizing effect, causing this type of engine to stop at intervals.

THOS. MORRIN said that he had had occasion a few years previously to inspect all of the carburetors made in the vicinity and that he found by using the carburetors in duplicate so that if one fouled a change could be made to the other and by feeding water into the inoperative one while it was still hot the deposit of dirt and carbon would slough off easily and it could be readily cleaned. The carburetor must be so constructed that it could be easily opened and tried out. If the oil was very dirty it might be necessary to have the carburetors in triplicate. No difficulty had been found in operating when the carburetors were cleaned with water or steam.

OIL FUEL FOR STEAM BOILERS

By B. R. T. Collins

ABSTRACT OF PAPER

This paper calls attention to the possible use of oil fuel for steam generating purposes in the Atlantic Coast States, discussing its safety and permanency of supply, as well as conditions under which it has special advantages over coal. Typical analyses of crude and fuel oil are given, with a statement of advantages and disadvantages when used for fuel as compared with coal. Some of the principles involved in efficient oil burning are stated, with a classification of oil burners or atomizers, several typical burners being illustrated and described. A statement of general methods of installation is made, with the data of some recent tests, showing the results which can be obtained from well designed installations properly operated.

The principles on which ultimate economy of oil versus coal depend are briefly stated. The opinion is expressed that there is a small, but gradually increasing field for the economical use of oil fuel for steam generating purposes in the Atlantic Coast States, and also that the success of any oil fuel installation depends less on the burner used than on the general efficiency of the entire installation and the intelligence with which it is operated after the installation is made.

OIL FUEL FOR STEAM BOILERS

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In view of the present gradually increasing cost of coal for steam generating purposes in the Atlantic Coast States and especially in New England, the question of a satisfactory and economical substitute naturally arises. Among various possible substitutes crude petroleum and its residual product, commonly known as fuel oil, have attracted more or less attention since the discovery of the Texas oil fields about ten years ago.

2 Fuel oil is more satisfactory for burning purposes than crude petroleum because it has had removed, by the process of partial distillation through which it has passed, practically all of the light and easily ignited products, such as naphtha, gasolene and kerosene, together with any water or muddy portion which the crude oil may contain. Hence, while the crude oil is burned with safety in tremendous quantities in the Gulf States and along the Pacific Coast under proper precautions, fuel oil, which has a considerably higher flash point and calorific value, can be used for fuel by men of ordinary intelligence with practically the same safety as coal.

3 The cost of fuel oil in the New England States has been decreasing recently so that at the present time it can be purchased there more cheaply than in the western part of Texas. This is due to the fact that the cost of transporting oil in tank cars to western Texas is greater per barrel than the cost of transporting it to New England in barges and tank steamers, the largest of which have a capacity of 100,000 bbl. each, containing the heat equivalent of 25,000 tons of high-grade coal. Advances in the construction and in the capacity of oil carriers have made it possible to transport petroleum and its products more cheaply than any other cargo and as safely, provided those who handle them use common sense and intelligence.

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4 Another reason for lower prices of petroleum products is the competition which now exists in the supply of these products for New England consumers. This condition tends also to keep prices on a more uniform and steady basis than was the case a few years ago when no competition existed.

5 The production of fuel oil at the present time is much greater than it ever has been, due partially to the great demand for gasolene for use by automobiles and other gasolene engines, thus producing more residuum and causing less crude oil to be burned in the immediate vicinity of the oil fields. This also causes more fuel oil to be available for shipment from Gulfport refineries.

6 This result is also partially due to the ease with which the crude oil is brought to the refineries by means of the increasing number of pipe lines which carry enormous quantities of oil at a rapid rate for hundreds of miles.

7 At present the major portion of the supply of oil for fuel purposes for the north Atlantic States comes from Texas, Louisiana, Oklahoma and Kansas, this group of States producing about 62,000,000 bbl. in 1909, or over one-third of the total production of petroleum for the United States in that year, in spite of the fact that California made an increase of over 20 per cent above her production of petroleum for 1908. During the year 1910 there was an increase to 72,000,000 bbl. in the production of crude oil in the states mentioned, as well as a phenomenal increase of 50 per cent in California, to 77,000,000 bbl., thus making the total production for the United States 216,500,000 bbl., or about two-thirds of the total production of crude petroleum for the world.

8 The interest that fuel users along the Atlantic coast have in California oil may seem at first thought to be very small, but with the opening of the Panama Canal now promised for 1915, a means will be provided for the easy and cheap transportation of California's surplus production to Atlantic coast ports. Furthermore, the strip of country between the mountain ranges and the Pacific Ocean in Mexico, Ecuador, Peru and Chili is known to be rich in petroleum, and with the completion of the canal all of this region as far south as Valparaiso, Chili, will be brought nearer to the Atlantic seaboard than the port of Los Angeles, Cal. Consequently, the permanency of the supply of liquid fuel would seem to be assured for a considerable period of years to come, especially after the opening of the Panama Canal.

9 It is understood, of course, that the supply of fuel oil at the pres-

ent time would take care of only a small portion of existing steam plants now using coal, but judging from the fact that the production of crude petroleum in this country increased over threefold during the last ten years, there should be sufficient fuel oil to take care of a gradually increasing class of plants which for various reasons and conditions can use it economically. Included in this class would be:

a Plants where the cost of handling coal by ordinary methods is higher than the average because of local conditions, and where the installation of suitable coal-handling equipment would not be warranted by the saving effected. For instance, a plant located on navigable water, but with the channel at a considerable distance from the shore, necessitating expensive wharves, docks, coal pockets and coal-handling equipment, in order to receive coal by water; or a plant at some distance back from the water front or at some elevation above it, or both, necessitating a similar large expenditure. In either of these cases, oil could be delivered to storage tanks located underground 30 ft. from the boiler room or above ground 200 ft. away for the cost of a properly installed pipe line and the power required to pump the oil from the barge into the storage tank; the barge being made fast to a few piles at the edge of the channel while unloading in the case where the channel is at some distance from the shore.

b Plants where boilers are fired by hand and more than one fireman is required on each shift. Take, for instance, a plant of four 500-h.p. boilers, requiring four firemen and possibly a water tender and coal passer on shifts where the full capacity of the boilers is required. With a proper fuel oil installation, one man could do all of the firing, water tending and tube blowing required and take care of the feed and oil pumps if located near the boilers, as well as all the polishing and cleaning required in the boiler room.

c Plants where greater capacity is required than can be obtained with the coal available. With oil, 35 per cent or more additional capacity can be obtained than with high-grade coal. This has been proved by plants in Pennsylvania changing from oil to coal and being obliged to install 35 per cent more boiler capacity to carry the same load as was carried before with oil.

d Plants where the boiler capacity is limited by the capacity of the existing stack or stacks and where it is not desired to install more stack capacity, although more boiler capacity must be obtained. Oil fuel can give this added boiler capacity without increasing the stack capacity, as the stack area required for the same boiler capacity with oil is only about 60 per cent of that required for coal.

e Plants where a very small amount of soot from the stack would cause damage to manufacturing processes if it entered the factory buildings. Oil can be burned with absolutely no smoke.

f Plants where it is necessary to keep smoke below certain fixed limits at all times, due to smoke ordinances.

OIL ANALYSES

10 In order to make comparisons between the calorific value and other properties of crude oil, fuel oil and any particular coal, Table 1 is given, with the authority therefor in each case.

TABLE 1 PROPERTIES OF CRUDE AND FUEL OIL

Oil	Field	Carbon	Hydrogen	Sulphur	Oxygen	Specific Gravity	Flash	Fire	B.t.u.	Authority
Crude	Sour Lake, Tex.	....	....	....	....	0.9266	198	.....	18460	Prof. A. C. Scott, Univ. of Texas
Crude	Beaumont, Tex.	....	....	....	....	0.9179	.....	.....	18500	
Crude	Beaumont, Tex.	84.6	10.9	1.63	2.87	0.9240	180	200	19060	U. S. Naval Liquid Fuel Board
Fuel	Beaumont, Tex.	83.3	12.4	0.50	3.83	0.9260	216	240	19481	
Crude	Whittier, Cal.	....	....	....	....	0.9416	.....	.....	18513	Prof. W. C. Blasdale, Univ. of Cal.

ADVANTAGES AND DISADVANTAGES OF OIL FUEL

11 The advantages of oil fuel may be summarized as follows:

a Calorific value per pound 30 per cent higher than that of high-grade coal, a less weight of oil being required to give the same heating effect.

b Space required for storage of oil is less than that for an equal weight of coal. Fifty per cent more heating value can be stored in the same cubic volume and at greater distance from the boilers without extra expense.

c Oil does not deteriorate by storage, as coal does to a greater or less degree, but maintains its heat value indefinitely in ordinary ventilated storage tanks.

d Lower temperature in boiler room.

e Area of stack 60 per cent of that required for coal for equal boiler capacity, thus enabling a plant having insufficient draft with coal to have an excess amount with oil, a change from coal to oil for fuel making installation of additional stack capacity unnecessary.

f Less heat lost up the stack, owing to cleaner condition of tubes and to smaller amount of air which has to pass through furnace for a given calorific capacity of fuel.

g Higher efficiency due to (1) more perfect combustion with less excess air, (2) more equal distribution of heat in combustion chamber, as doors do not have to be opened, and (3) small amount of soot deposited on the tubes.

h Increase in capacity of 35 per cent to 50 per cent over coal, depending on grade of coal and draft conditions with coal.

i Heat is easier on the metal surfaces, being more evenly diffused over the entire heating surface of the boiler.

j Ease with which fire can be regulated from a low to a most intense heat in a short time or entirely extinguished instantly in case of emergency, such as water dropping out of sight in gage glass, and quickly relighted when the emergency is over. In less than half an hour a boiler can be brought up to 150 lb. steam pressure from cold water, if necessary. By means of an automatic regulator varying the pressure of oil and steam or air to the burners or atomizers, the steam pressure can be maintained within 5 lb. total variation, with sudden changes in load amounting to 50 per cent and over.

k Smoke can be entirely eliminated.

l No cleaning of fires, thus boilers can maintain their maximum capacity continuously, if necessary.

m Much lower cost for handling oil, as it runs by gravity or is pumped into and out of storage to the boilers.

n Absence of coal dust and ashes, thus enabling everything in the boiler room to be kept clean; therefore less wear and tear on pumps or other machinery. No expense for handling and removing ashes.

o No firing tools used, consequently no damage to furnace linings from this source. No clinkers to be removed from grate bars or furnace side walls.

p Less shrinkage and loss in handling oil fuel than in handling coal.

q Great saving of labor of all kinds: firemen, coal passers, ash wheelers, tube blowers, etc.

12 The disadvantages of oil fuel are:

a Low flash point. Fuel oil should have a flash point not lower than 140 deg. fahr., and with oil of this quality, handled by men of ordinary intelligence and common sense, there is practically no more danger than with coal.

b The ordinary underwriters' or city requirements specify that storage tanks for fuel oil be located underground and at least 30 ft. from the nearest building. This can generally be complied with in the case of the power plant of the average manufacturing concern, but in the case of a plant in the congested districts of a city it is likely to be prohibitive.

c With boilers using feed water of considerable scale-making qualities, the cost of repairs is likely to be increased by changing to oil, owing to the intense temperature developed in the furnace. However, with a proper setting for burning oil, repairs due to overheated tubes or surfaces should be less than with coal, unless the feed water is very bad.

PRINCIPLES INVOLVED IN EFFICIENT OIL BURNING

13 The requirements for the perfect combustion of liquid fuel are as follows: Reduction to a fine spray or complete atomization; bringing it into contact with the proper amount of air; mixture of oil spray and air burned in a furnace of a refractory material with room enough to complete combustion before the gases come in contact with the boiler heating surfaces.

14 The first condition is fulfilled by selecting a proper burner, and the remaining conditions can generally be obtained by making slight changes in, or additions to, the existing furnaces.

15 The question whether to use steam or air for atomizing the oil seems generally to have been decided in favor of steam, as experimental results show that it takes about the same amount of steam

to operate the air compressor as it does to atomize the oil at the burner and the additional investment and complication involved with greater possibility of interrupted service is avoided.

16 It is also easy to see that a flat fan-shaped flame presents a larger surface for heat radiation and uniform distribution of gases than any other shaped flame, and at the same time requires a minimum number of burners per boiler.

17 Heating of the oil is an aid to economical combustion, and should take place as near the furnace as possible and be carried as high as safety permits, but not so high as to cause the oil to decompose and carbon to be deposited in the supply pipes. If preliminary heating is limited to the temperature of the flash point of the oil used, there can be no trouble from the above-mentioned causes.

18 In oil burning, although a certain amount of skill is required for hand adjustment of the burners to obtain the best results, still, with automatic regulation, the skill is reduced to a minimum, the principal work of the fireman being to see that the oil pump is kept in constant operation and that the burners do not become clogged with small particles of foreign matter, scale, etc., especially when the installation is new. Strainers of proper design, however, introduced on the suction line to the pump and also between the pump and the burner, will reduce this trouble to a minimum. Burners should be so installed that they can be easily disconnected from the piping and taken from the furnace for the removal of any foreign substance from their restricted orifices.

19 One of the most important questions in the combustion of liquid fuel is the regulation of the air supply in such a way as to obtain perfect combustion before the gases come in contact with the heating surfaces of the boiler. This can be done with an automatic damper regulator, although its adjustment is rather difficult. It is therefore usually accomplished by hand regulation of the damper when considerable variations in the load take place. This is supplemented by changing the position of the ash-pit doors, which are kept partly closed until a slight tendency to make smoke is noticed in the furnace when they are opened until this tendency disappears; or, better, by using an Orsat or continuous CO_2 gas analyzer to determine the position of damper and ash-pit doors which gives most complete combustion under certain constantly recurring conditions.

TYPES OF OIL BURNERS

20 Although thousands of patents have been granted for oil burners or atomizers two general subdivisions or five general classes, as designated by the U. S. Naval Liquid Fuel Board, cover practically all of the main features of construction.

21 The two general subdivisions are:

a *Outside mixing.* Oil and atomizing agent meet outside the burner.

b *Inside mixing.* Oil and atomizing agent meet inside the burner.

22 The five general classes included in Par. 21 are:

c *Drooling.* Oil oozes out on to steam or air jet.

d *Atomizing.* Oil is swept from orifice by steam or air jet.

e *Chamber.* Oil mingles with steam or air in body of burner and the mixture issuing from nozzle is broken into minute particles by the expansion of the steam.

f *Injector.* Similar in principle to boiler feeding injector.

g *Mechanical spraying.* Effected by mechanical means without the use of atomizing agents, such as steam or compressed air.

23 The important features which should be embodied in all burners are: easy method of installation, construction that will allow quick inspection, easy removal of all foreign material which may clog the burner at any point and rapid and cheap renewal of any parts which are subject to wear.

METHOD OF INSTALLATION

24 In spite of the various principles involved in burner construction, the success of an oil fuel installation depends not so much on the type of burner or atomizer used as on the method of its installation, and the intelligence with which it is operated after the installation is made.

25 To conform with the underwriters' requirements, storage tanks above the surface of the ground should be placed at least 200 ft. from inflammable property, and the top of the tanks should be located below the level of the lowest pipe used in connection with the apparatus. When the tanks are located underground, they should be outside the building, at least 2 ft. below the surface and 30 ft. from any building, with the top of the tanks below the lowest pipe in the building used in connection with the apparatus. In small and medium

sized installations, steel tanks coated with tar, having a capacity of 8500 to 15,000 gal. each, or 200 to 370 bbl. of 42 gal., are generally used for storage. In larger installations, reinforced concrete tanks, generally rectangular in shape, are used. These are usually made with a partition in the centre, so that any sediment or thick material may be periodically cleaned out without interfering with the continuous supply of fuel. The capacity of the storage tanks may vary from a supply sufficient for two weeks, when the oil is near at hand, and more may be obtained on one day's notice, to a supply sufficient for two or three months when the source of supply is at a considerable distance and delivery is in large quantities at irregular intervals.

26 Storage tanks should be fitted with vent pipes, indicators showing level of oil in tanks, filling pipes, arrangements for freeing tanks from water, suction pipes, return or overflow pipes, steam pipes for filling space in tanks above oil with steam in case of fire, and suitable manholes for cleaning out purposes. A suitable strainer should be installed on the suction line between the storage tanks and the oil-pressure pumps. The suction line should slope so that it will drain all oil back to the storage tanks when the pump is stopped and a vent opened.

27 Duplicate oil-pressure pumps should be installed with pump governors and all piping in connection with these pumps should be cross-connected in such a manner that a change can be made from one to the other and repairs made to either without interrupting the service.

28 A suitable oil heater should be installed, so that the exhaust steam from the oil pumps can be utilized to heat the oil before it reaches the burners. A suitable relief valve should be installed on the discharge line between the pumps and the burners set at a definite maximum oil pressure.

29 An oil meter should also be installed in the discharge line to check the storage-tank indicator readings. All oil piping should be installed so that it can be drained back to the storage tanks by gravity in case of necessity.

30 Provision should be made for removing any condensation from the steam lines to the burners. Automatic regulating devices should be installed to vary the pressure of both oil and steam to the burners in accordance with the demand for steam on the boilers, thus keeping a uniform steam pressure with a variable load, relieving the fireman of constant adjustment of burner valves and enabling him to take care of a much larger capacity of boilers than he otherwise could.

31 In case a plant is operated only ten hours per day, no steam being required for the rest of the 24 hours, it is necessary to install a small auxiliary boiler for the purpose of providing steam to atomize the oil while firing up the main boilers. In case of horizontal return tubular or Heine boilers, the burners should be placed at the front,

TABLE 2 GENERAL DATA AND RESULTS OF

Date of test, 1910	Aug. 8
Test number	1
Duration of test, hours	7
Steam pressure, lb	184.9
Steam temperature. deg. fahr	473.3
Superheat, deg. fahr	91.8
Feed water temperature, deg. fahr	90.6
Factor of evaporation	1.237
Average water level, in	4
Barometer, in	29.97
Temperature boiler room, deg. fahr	88.7
Temperature flue gases, deg. fahr	385.3
Draft, in. In ash pit	0.025
In furnace	0.01
In rear pass	0.005
Carbon dioxide, per cent	12.2
Oxygen, per cent	3.6
Excess air, per cent	28.7
Smoke	None
Temperature first pass above third tube, deg. fahr	1100
Temperature top first pass, deg. fahr	640
Temperature top second pass, deg. fahr	570
Temperature bottom second pass, deg. fahr	500
Temperature bottom third pass, deg. fahr	450
Total water actually evaporated, lb	85766
Total water evaporated from and at 212 deg. fahr., lb	106092
Water evaporated from and at 212 deg. fahr., lb. per hr	15156
Steam used by burners, lb. per hr	234
Steam used by burners, per cent of total steam	1.54
Steam pressure to burners, lb	48.2
Oil pressure to burners, lb	11.4
Temperature of oil to burner line, deg. fahr	131.3
Specific gravity of oil at 60 deg. fahr	0.9770
Specific gravity of oil, Baumé, at 60 deg. fahr	13.3
Moisture in oil, per cent	0.4
Heat value of oil as fired, B.t.u	18280
Heat value of oil corrected, B.t.u	18353
Total oil as fired, lb	6913
Total oil corrected for moisture lb	6885
Oil fired, lb. per hr	987
Oil corrected, lb. per hr	983
Water evaporated from and at 212 deg. fahr. per sq. ft. heating surface, lb.	2.58
Boiler horsepower builder's rating	604
Boiler horsepower developed	439.3
Per cent of builder's rating	72.7
Water evaporated per lb. of oil from and at 212 deg. fahr. Oil as fired, lb	15.35
Corrected for moisture, lb	15.41
Boiler efficiency, per cent	81.1

firing towards the bridge wall. However, in the case of boilers of the Babcock and Wilcox type, higher efficiency can be obtained by placing the burners at the bridge wall and firing towards the front of the boiler.

32 It is sometimes an advantage to be able to change quickly from oil to coal and from coal to oil. This arrangement can generally

TESTS ON OIL-BURNING BOILER, REDONDO, CAL.

Aug. 9	Aug. 10	Aug. 11	Aug. 12	Aug. 13	Sep. 5	Average of all tests
2	3	4	5	6	7	
7	7	7	7	7	7	7
184.9	186.0	184.7	183.5	184.6	184.9	184.8
457.4	468.8	465.1	473.8	493.8	526.7	479.8
76.0	86.9	83.7	93.0	112.5	144.3	98.3
92.6	92.7	93.4	90.8	94.6	101.2	93.7
1.225	1.232	1.229	1.237	1.245	1.259	1.238
4	4	4	4	4	4	4
30.00	30.00	30.09	30.08	30.04	29.68	29.97
86.6	84.4	85.2	87.3	86.7	84.4	86.2
397.5	409.1	406.2	429.0	477.1	537.5	434.5
0.035	0.055	0.044	0.071	0.127	0.230	0.084
0.005	0.025	0.014	0.060	0.130	0.188	0.062
0.014	0.061	0.046	0.133	0.296	0.471	0.147
13.4	13.3	14.3	14.2	13.3	12.1	13.2
2.7	2.4	1.8	1.7	2.8	6.8	3.1
17.7	18.5	10.6	11.3	18.5	43.0	21.2
None	None	None	None	None	Light haze	......
1090	1160	1180	12.40	1300	1600	1240
640	700	680	780	940	1170	793
540	620	610	650	740	820	.650
500	520	510	550	600	700	554
450	505	495	530	570	660	523
111988	129628	129609	156622	191290	226558	147351
137185	159702	159289	193741	238156	285236	182771
19598	22814	22756	27677	34022	40748	26110
441	549	549	624	708	873	568
2.25	2.40	2.40	2.25	2.08	2.13	2.15
74.7	99 7	102.6	120.4	142.5	167.6	122.2
15.2	24.4	25.4	38.3	46.1	61.6	31.6
134.3	133.5	142.3	140.1	142.1	141.7	137.9
0.9770	0.9763	0.9770	0.9776	0.9776	0.9797	0.9776
13.3	13.4	13.3	13.2	13.2	12.9	13.2
0.5	0.45	0.4	0.8	0.65	0.6	0.54
18256	18131	18253	18214	18171	17985	18184
18347	18212	18326	18357	18289	18093	18281
8758	10322	10115	12602	16580	20205	12213
8714	10276	10075	12501	16472	20084	12144
1251	1474	1445	1800	2369	2887	1745
1245	1467	1439	1786	2353	2869	1735
3.24	3.78	3.77	4.58	5.63	6.74	4.32
604	604	604	604	604	604	604
568.0	661.3	659.6	802.2	986.2	1181.0	756.8
94.0	109.4	109.2	132.8	163.3	195.5	125.3
15.66	15.47	15.75	15.37	14.37	14.12	15.15
15.74	15.54	15.81	15.49	14.46	14.20	15.23
82.8	82.4	83.3	81.5	76.4	75 8	80.47

be provided for, although in some cases, on account of a lack of sufficient combustion chamber space, a more efficient furnace may be installed by making the change back to coal a somewhat longer process, requiring the insertion of bearer bars and grate bars, which would be left in place in the arrangement first referred to.

TESTS OF OIL-BURNING BOILERS

33 Table 2 gives the data and results of a series of tests recently made by The Pacific Light and Power Company at their plant, Redondo, Cal., on a 604-h.p. Babcock and Wilcox boiler equipped with Hammel furnace and burners. The boiler was in regular service and under usual plant operating conditions. The ash-pit doors were wide open during all tests. The tests were under the direction of Frank T. Clarke of the power company. Six of the tests were conducted on six consecutive days. The boiler used for testing was No. 1, in battery 1, erected in 1906; heating surface, 6042 sq. ft. The oil used was crude from the Los Angeles fields, the calorific value being obtained by the New York Testing Laboratory, Los Angeles branch.

34 It will be noted that the average temperature of the flue gases is 435.5 deg. fahr. with a minimum of 385.3 deg. fahr. at 72.7 per cent of rating, and a maximum of 537.5 deg. fahr. at 195.5 per cent of rating. The average per cent of CO_2 is 13.2, and excess air 21.2 per cent; steam used by burners 2.15 per cent. The highest efficiency obtained was 83.3 per cent. This was on the test of August 11, while running at 109.2 per cent of the builder's rating, and the water evaporated per pound of oil from and at 212 deg. fahr., corrected for moisture, was 15.81 lb. The average efficiency for all seven tests, running from 72.7 per cent up to 195.5 per cent of rating, was 80.47 per cent, and the average evaporation from and at 212 deg. fahr. was 15.23 lb.

35 In Table 3 are given results of tests made at the Ravenswood plant of The New Amsterdam Gas Company, Ravenswood, N. Y. These tests were made on a 595-h.p. Babcock and Wilcox boiler, equipped with a Peabody furnace and four No. 1 burners. The tests were made for the company by N. E. Lewis. The boiler had 5946 sq. ft. of boiler heating surface, and 841 sq. ft. of superheating surface. The fuel used was a low grade of fuel oil, hardly higher in heat value than gas-house tar. Attention is called to the fact that only 1.43 per cent and 1.51 per cent respectively of the steam generated was used to atomize the oil in the burners. The two series of

tests show the results that can be obtained with good oil-burning equipment well installed and properly operated.

RELATIVE COST OF OIL AND COAL

36 A tabulation could be made showing the number of barrels of oil equivalent to a ton of coal of varying calorific value, but this would be of very little practical value taken alone, for the reason that the efficiency of a boiler using oil fuel would be from 5 per cent to 15 per cent higher than when using coal, due to more perfect combustion with oil. The gain in efficiency would vary with the size of the boilers, character of furnaces and other equipment, intelligence of firemen, etc.

TABLE 3 GENERAL DATA AND RESULTS ON TESTS ON OIL-BURNING BOILER, RAVENSWOOD, N. Y.

Number of test		4760	4761
Date of test, 1907		July 2	July 3
Duration of test, hours		5	4
Steam for atomizing, superheated or saturated		Saturated	Saturated
Steam pressure by gage, lb		145	142
Temperature of feed water, deg. fahr		132.4	119.6
Degrees of superheat, deg. fahr		85	83
Factor of evaporation		1.1750	1.1868
Total oil burned, lb		8273	6687
Oil burned per hour, lb		1655	1672
Total water evaporated, lb		101546	82317
Total water evaporated from and at 212 deg. fahr., lb		119317	97694
Water evaporated per hour from and at 212 deg. fahr., lb		23863	24423
Draft, boiler side of damper, in		0.29	0.29
Draft in furnace, in		0.16	0.15
Temperature waste gases in flue, deg. fahr		488	488
Temperature air in boiler room, deg. fahr		89	82
Temperature oil at burners, deg. fahr		97	97
Flue gas analyses	Carbon dioxide, per cent	13.14	13.25
	Oxygen, per cent	5.29	5.15
	Carbon monoxide, per cent	0	0
Water evaporated per sq. ft. boiler heating surface per hour from and at 212 deg. fahr., lb		4.01	4.11
Water evaporated per sq. ft. total heating surface per hour from and at 212 deg. fahr., lb		3.52	3.60
Water evaporated from and at 212 deg. fahr. per lb. of oil		14.42	14.61
Horsepower developed		691.7	707.9
Per cent of rated capacity developed		116.2	118.9
Steam used by burners per hour, lb		340	377
Per cent of steam generated used by burners		1.43	1.54
Net water evaporated from and at 212 deg. fahr. per lb. of oil (allowing for steam used by burners)		14.21	14.38
B.t.u. per lb. of oil		17733	17425
Efficiency based on gross evaporation		78.53	80.97

37 Although a fair idea may be obtained of the comparative cost of the two fuels by making certain assumptions in regard to heat values, specific gravity, gain in efficiency, etc., still this will not enable one to figure the saving which could be made by changing from one fuel to the other. The reason for this is that the saving generally depends on other things than the cost of the fuel. The saving in firemen and coal passers, increase in capacity, facilities for fuel storage, advantage of pumping fuel over methods of handling coal, elimination of handling ashes, quantity of coal used for banking fires, elimination of smoke and other things, many of which cannot be figured out in advance in dollars and cents, would throw the ultimate cost decidedly in favor of oil. The only way to determine the exact saving is to operate the plant with each fuel for a long enough period to get accurate data on all the items entering into the question.

CONCLUSION

38 The writer believes that there is a comparatively small, but gradually increasing field for the use of oil fuel for steam generating purposes in New England in plants where special conditions enable a net saving to be made when everything entering into the problem is taken into consideration.

39 The writer also believes that the success of any oil-fuel installation depends less on the type of burner or atomizer used than on the general efficiency of the entire installation and the intelligence with which it is operated after the installation is made. Therefore, the work of designing and constructing such installations should be entrusted only to those having had extended practical experience in burning oil fuel and the operation of these installations should not be given to unskilled labor, for, in order to obtain the economic results possible from the use of oil fuel, it will be necessary to employ men of intelligence and skill as firemen.

APPENDIX No. 1

40 A few typical burners representative of the subdivisions and classes mentioned in Par. 20 are shown in Figs. 1-13. Although these cover only a few of the burners and furnaces now in use in this country, not to mention the large number of systems of oil burning, the writer believes that they are sufficiently typical to show general principles involved, which is all he can attempt in this paper. The author is responsible for the general classification given in the case of each burner, but the details of construction and operation are as given by the manufacturers in their descriptive literature.

Fig. 1 Peabody No. 1. Outside mixing. Drooling. Fan-shaped flame. Spraying from sharp edge. The cut shows clearly the details of construction, including oil strainer, steam by-pass for blowing out oil passages, oil pipe jacketed by steam and removable burner tip.

41 This tip contains two very narrow slots separated by a diaphragm, the lower slot for steam and the upper for oil. The oil falls at right angles upon the steam jet which atomizes it and the oil is burned in a fan-shaped flame. It will be noted that the tip is held in position by a single bolt so that it can be readily cleaned if necessary. The mixing or atomizing is done entirely outside the burner. This style is for use in connection with the Peabody furnace, in which the burner tip is located at the bridge wall and the flame projected towards the front of the boiler.

Fig. 2 Peabody No. 2. Similar to Peabody No. 1 except that it is designed to be placed at the front of the boiler and to project the flame toward the bridge wall in the ordinary manner.

Fig. 3 W. N. Best high-pressure oil burner. Outside mixing. Atomizing. Long slot. Spraying from sharp edge. The air or steam meets the oil at right angles, thus atomizing it externally. Either a long narrow flame or a fan-shaped flame can be provided as required.

Fig. 4 W. N. Best oil burner with piping connections. Same as Fig. 3, except fitted with piping of sufficient length to go through the front setting of boiler. By-pass is provided for blowing out any foreign substance that enters the oil pipes. The atomizer lip is hinged and means provided for raising the lip for blowing-out purposes without removing the burner from the boiler.

Fig. 5 Gem oil burner. Outside mixing. Drooling. Rose-shaped orifice. Spraying aided by centrifugal action from internal screw and cone. Oil heated by atomizing steam on the way to burner tip as it surrounds oil pipe.

Fig. 6 Gilbert and Barker oil burner. Outside mixing. Drooling. Rose-shaped orifice. Spraying aided by slight centrifugal action from internal helix. Adapted for use where very heavy consumption of oil is required, such as heavy metallurgical operations, brick kilns, etc.

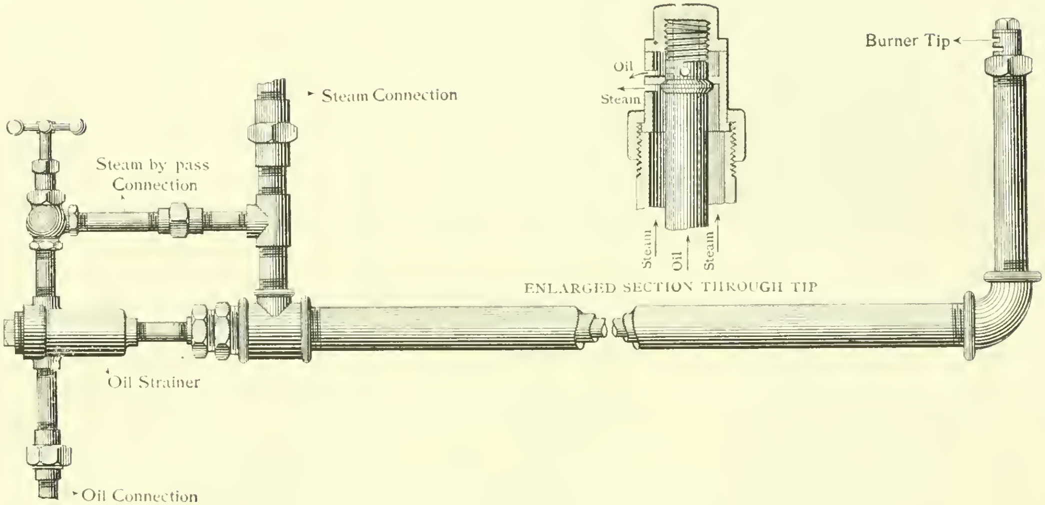


FIG. 1 PEABODY NO. 1 OIL BURNER

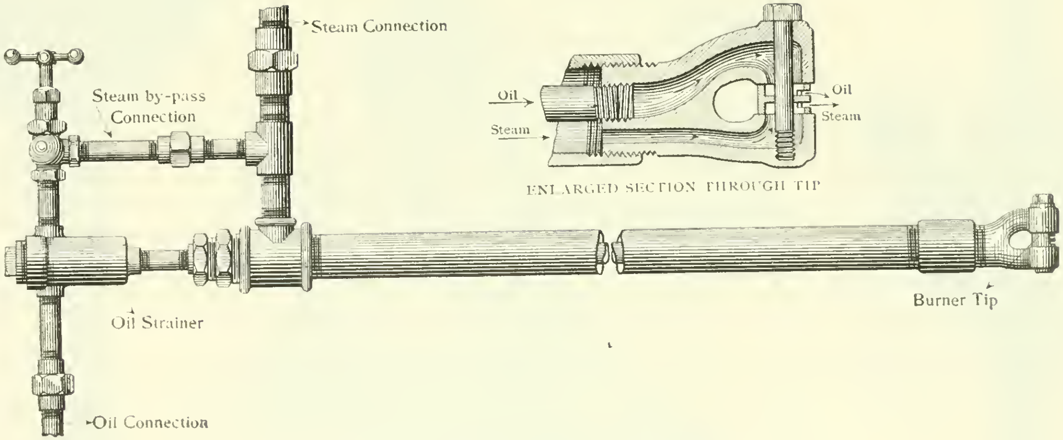


FIG. 2 PEABODY NO. 2 OIL BURNER

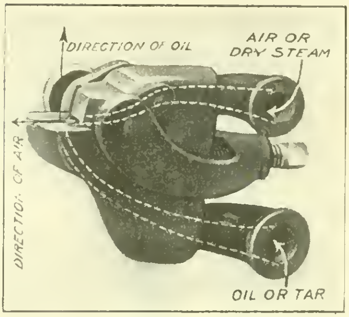


Fig. 3 W. N. Best High-Pressure Oil Burner

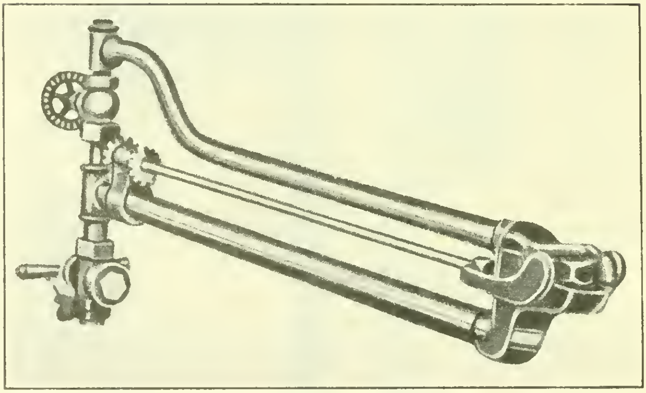


Fig. 4 W. N. Best High-Pressure Oil Burner with Piping Connection

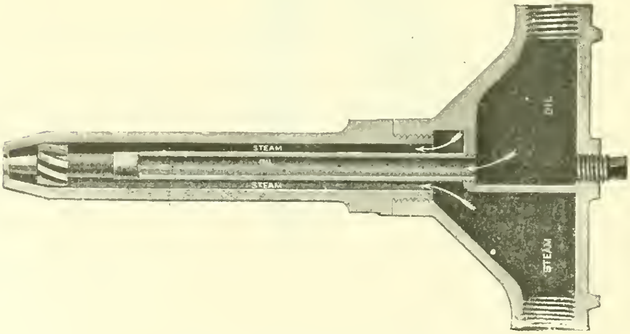


Fig. 5 Gem Oil Burner

Fig. 7 Rockwell high-pressure oil burner. Outside mixing. Atomizing. Steam or air and oil nozzles removable for cleaning-out purposes. Steam or air nozzle outside of oil nozzle. Adapted for light or heavy work.

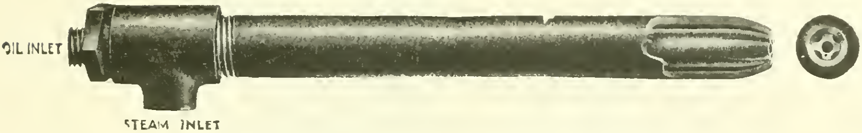


Fig. 6 Gilbert and Barker Oil Burner

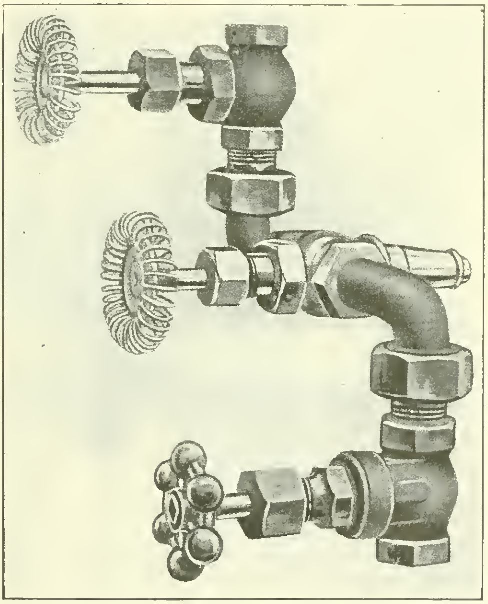
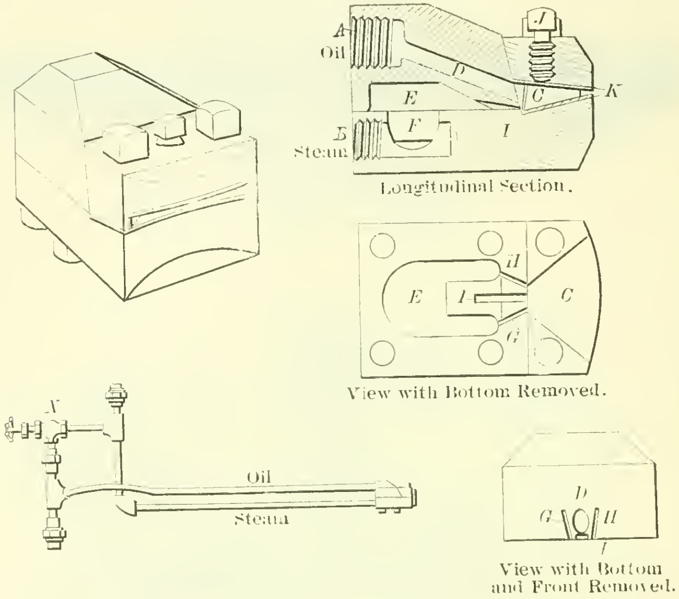


Fig. 7 Rockwell High-Pressure Oil Burner

Fig. 8 Hammel oil burner. Inside mixing. Chamber and atomizing. Long slot. Spraying from sharp edge. All parts are named in the cuts. Oil enters at *A* and flows through *D* into mixing and atomizing chamber *C*; steam enters at *B* passes through *F*, *E* and then through three small slots, *G*, *H* and *I* into mixing chamber *C*, where it meets the oil. The small steam jets break up the oil in the mixing chamber and the mixture is ready for ignition as it issues from the fan-shaped orifice. This orifice is provided with removable steel plates, which can be replaced easily in case of wear.

Fig. 9 Kirkwood oil burner. Inside mixing. Injector. Rose-shaped orifice. Spraying from sharp edge. Both oil and steam valves seat at tip of the burner and are equipped with indexes showing the amount of oil and steam turned on.



Longitudinal Section.

View with Bottom Removed.

View with Bottom and Front Removed.

Fig. 8 Hammel Oil Burner

A Orifice for Oil Supply Pipe. *B* Orifice for Steam Supply Pipe. *C* Mixing or Atomizing Chamber. *D* Oil Inlet Duct. *E* Equalizing Steam Chamber. *F* Steam Entrance. *G, H, I* Steam Ducts. *J* Set Screw holding Plate. *K* Removable Steel Plates. *X* By-Pass or Blow-Out Valve.

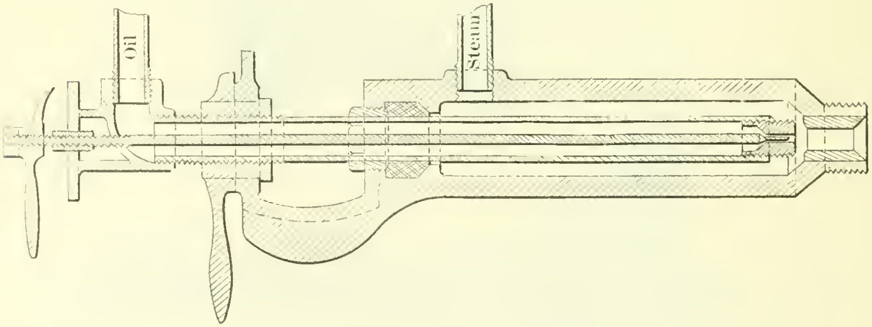


Fig. 9 Kirkwood Oil Burner

In another style of this burner one lever controls both the oil supply and the steam necessary for atomizing, the proportion being fixed before shipment from factory.

Fig. 10 Improved Little Giant oil burner. Inside mixing. Chamber. Double long slot. Spraying from sharp edges. Oil pipe surrounded by steam

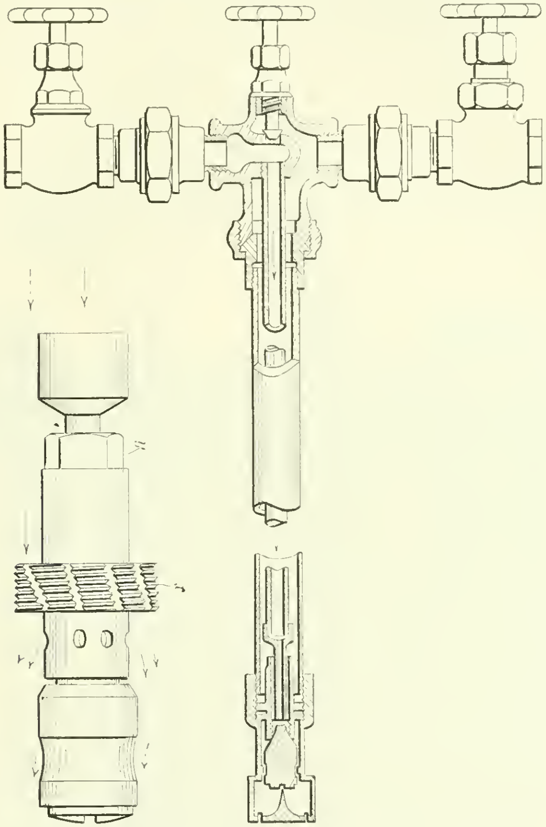


Fig. 10 Improved Little Giant Oil Burner

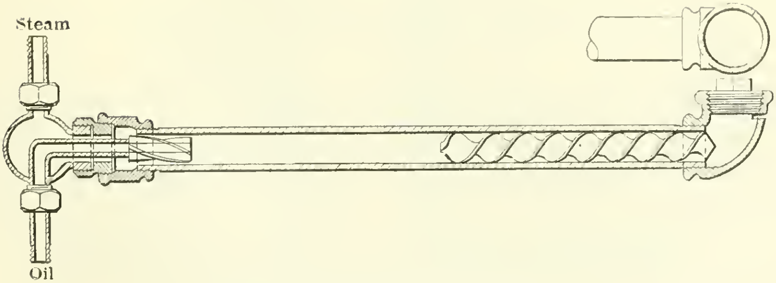


Fig. 11 Texas Oil Burner

which enters mixing chamber near tip. A separating diaphragm causes an equal amount of the mixture of oil and steam to issue from each opening in the tip. A special non-clogging oil valve is used.

Fig. 11 Texas oil burner. Inside mixing. Chamber. Fan-shaped flame. Spraying aided by centrifugal action from internal screw. As the oil flows into

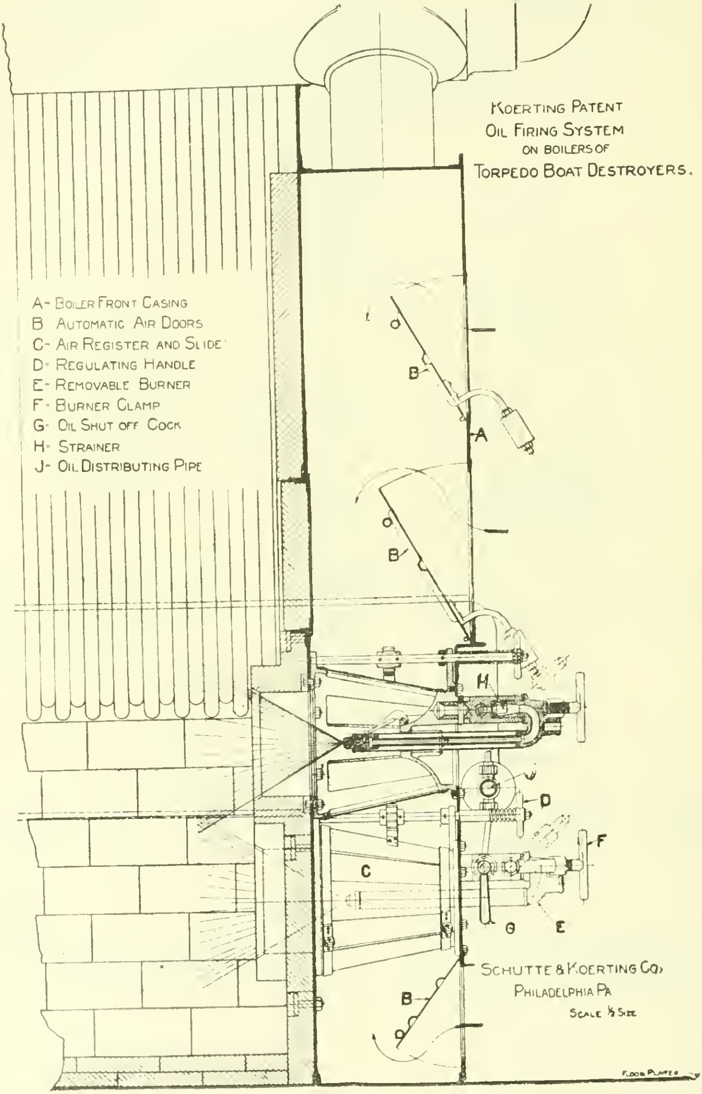


Fig. 12 Koerting Oil Burner

the large mixing chamber it is picked up by the steam to which rotary motion has been imparted by a short helix in the steam passage just back of the oil inlet. The mixture then passes along the chamber through a spiral passage occupying about one-half of its length which sets up a strong centrifugal action so that the oil is thoroughly atomized and vaporized when it issues from the fan-shaped orifice in the small chamber at the tip of the burner. This orifice is made to give any width of flame required and the tip is easily renewable in case of wear.

Fig. 12 Koerting oil burner. Mechanical spraying by pressure and centrifugal action from internal screw. Oil is delivered to the burner under sufficient pressure to break it up into a conical spray with the aid of spiral blades which set up a strong centrifugal action and a central cone at the tip which helps to maintain the centrifugal effect until the oil issues from the orifice. By loosening the clamp screw and throwing it into the dotted position shown, all working parts of the burner are quickly removable for examination or cleaning. The supply of air is introduced through adjustable openings shown in the cut so that it will impinge directly on the spray of oil thus effecting immediate combustion. The fact that this burner requires neither steam nor compressed air for atomizing makes it especially desirable for marine and naval boilers where fresh water for boiler feed make-up purposes is expensive.

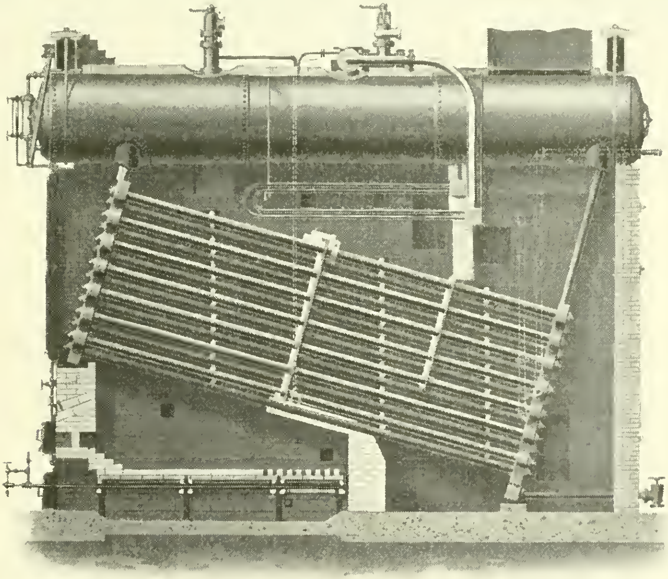


Fig. 13 Peabody Furnace for Liquid Fuel

Fig. 13 Peabody furnace for liquid fuel. E. H. Peabody of the Babcock and Wilcox Company, while making an exhaustive study several years ago of

methods of burning oil under water-tube boilers, discovered that by placing the burners at the bridge wall and projecting the flame toward the boiler front a large gain in efficiency and capacity could be made. This gain is due to the thorough distribution of the flame through the furnace and the complete combustion of the gases before coming into contact with the boiler tubes as well as the consequent improved utilization of the entire heating surface in the first pass of the boiler. All details of the furnace are clearly shown in the cut, including extension of furnace towards the rear of the boiler, arrangement of air openings, method of supporting burners and inserting them through special slide ways supported on the bearing bars which hold the floor of the furnace.

42 The Hammel furnace, used in the tests in Table 2, is based on the Peabody patent furnace (Fig. 13) with the addition of a slot in the bridge wall in which the burner is placed for protection from the heat and a separate air tunnel to each burner so that one or more burners may be extinguished and their air supply entirely shut off, thus maintaining the efficiency of the burners still in use.

DISCUSSION

E. H. **Peabody** judged that the reference to the steam consumption of the oil burners, in Par. 33, pertained to the tests made by N. E. Lewis at the Ravenswood works of the New Amsterdam Gas Company, the results of which are given in Table 3. These tests were two incidental runs made in a series of experimental tests mainly with gas-house tar as fuel. It was not expected that they would achieve the distinction of appearing in the proceedings of the Society, and while very good tests, they should not be taken as a fair comparison of results obtained with Hammel burners, as their proximity to Table 2 of the paper would seem to indicate. In reference to Par. 42, Mr. Peabody said that in his original study of oil furnaces in California, he had experimented with separate air ducts or tunnels to the individual burners, and the earliest installations of the Peabody furnace on the Pacific coast in 1903 embodied this idea.

M. H. **Bronsdon**[1] stated that every one of the tests of crude or fuel oil made for him by Professor O'Neill at the University of California showed the same calorific value (practically), regardless of its specific gravity or whether or not the gasolene had been removed. The more fluid the oils, the less troublesome they were, as they required a much lower pressure to send them through the piping; and where the specific gravity is 17 deg. Baumé, or lighter, at 60 deg. fahr., no warming during the pumping process was necessary.

The use of fuel oil removes one of the most important and expensive items of power plant operation from the hands of unskilled labor (i.e., the ordinary fireman), and places it upon an efficient basis, as with proper installation economical operation is dependent only upon reliable and very simple mechanism.

Where oil is used for fuel, perfect combustion may be obtained under all conditions of load with proper installation, excepting when the fires are first lighted and the brick work is comparatively cold. Boiler settings and boiler tubes last much longer with fuel oil than with coal, provided the tubes are kept clean.

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[1] Chief Engineer, The Rhode Island Co., Providence, R. I.

Presented at the Boston Meeting, April 1911, of The American Society of Mechanical Engineers. All discussion is subject to revision.

The impression should not be given, as stated in Par. 11, that by changing from coal to fuel oil the capacity of any boiler plant can be increased to from 35 to 50 per cent. In boiler plants with sufficient draft to burn large quantities of coal, or where the evaporation can be made to exceed, say 7 lb. of water per sq. ft. of heating surface, fuel oil will not increase the capacity 35 to 50 per cent.

His experience led him to favor burners of the type known as "outside mixers," i.e. where the oil and steam mix just beyond the tip of the burner. Carbon seldom causes trouble with burners of this type, even where the oil is quite hot before it reaches the burner. There seems to be no practical difference in the efficiency, however, in the use of either inside or outside mixer burners.

In a well designed and carefully operated boiler plant using coal for fuel, where the efficiency is approximately 75 per cent or better, the use of fuel oil will not change the efficiency materially. In a plant which operates from 20 to 24 hours a day, the standby losses will, of course, be lower with oil than with coal, due to the fact that there are no banked fires to be maintained under spare boilers, some of which are of use only during the peak load conditions. The gain in efficiency is not due simply to the use of fuel oil, but rather to better conditions which are maintained with less effort, such as the removal of soot from the tubes, cleaner back connections, and the fact that the fireman is not fatigued by his labors, but can without any particular effort see that perfect combustion is maintained. The CO_2 recorder becomes a valuable instrument in a boiler room using oil for fuel.

Comparing the cost of fuel oil with coal, we should consider, first, the cost of coal alongside, plus discharging costs, plus conveyor costs, plus the cost of removing ashes; second, the B.t.u. per ton of coal. In New England at tidewater, the cost of coal, and the discharging and conveying costs and the removal of ashes approximate \$3.50 per ton, varying from year to year. One ton of bituminous coal contains approximately 33,000,000 B.t.u. and we should buy 33,000,000 B.t.u. in fuel oil for approximately \$3.50; i.e., 33,000,000 B.t.u. equals

1774 lb	\$3.50
224 gal	3.50
1 gal	0.0156
1 bbl	0.65

These figures will be slightly reduced if credit is given for minor economies resulting from the use of oil, but they are amply accurate for general use.

D. S. Jacobus said that the efficiency results given in Table 2, secured in tests on an oil-burning boiler at Redondo, Cal., represented good practice. Better results, however, were secured in tests on one of the boilers at the same plant preparatory to making a test of the plant. The plant tests, already reported to the Society, indicated that a kilowatt-hour was turned out at the switchboard for each 25,000 B.t.u. contained in the fuel oil. In these tests the standard form of Peabody furnace was employed with burners of the outside mixer type.

S. F. McIntosh[1] believed that there is little to choose between the two when figuring on oil at $0.03 a gallon and coal at $5.00 a ton delivered in the boiler house on the B.t.u. basis. At the plant of the American Optical Company, Diesel engines were installed, and as more or less oil equipment was required for their operation, it was decided to try oil under the boilers. It has worked almost perfectly and there has been no trouble whatsoever. Its advantages in the way of ease of operation, cleanliness, efficient combustion, etc., appeal to them strongly. If, however, many manufacturers in New England should become interested and burn oil for the same reason, there would be no doubt that the price per gallon would increase to a point where it would be impossible to burn oil economically anywhere in New England. His firm contracted for oil during 1911 at $\frac{3}{10}$ cent a gallon more than in 1910, which is equal to an increase in the price of coal of 16 cents per ton at the mine. A slight increase in the price of oil offsets the saving of labor through its use. Taking the statement of the author that one man can handle four 500-h.p. boilers under which oil is used, where four men would be required if coal were used, and assuming the saving in labor to be 80 cents an hour, an increase of $\frac{1}{10}$ cent in the price of oil would entirely offset the saving in labor.

B. R. T. Collins referred to the fact that Mr. Bronsdon had had his experience with fuel oil in California, where the crude oil is quite different from the residue from Texas, which would alter his conclusions somewhat. The reason for more complete combustion referred to by Mr. McIntosh is that there is no loss in burning oil such as occurs in burning coal, at the period just after the coal is fired, especially with hand firing. At that time a large quantity of hydrocarbons are only partly consumed. It therefore stands to reason that an oil-burning equipment should be more efficient. There are more heat units of the oil utilized in producing steam than of the coal in an ordinary coal-burning installation.

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[1] American Optical Co., Southbridge, Mass.

In reply to an inquiry as to why oil could not compete with coal in modern plants using mechanical stokers, where from 75 to 80 per cent efficiency can be obtained, Mr. Collins replied that in large plants burning 100 or more tons of coal a day having docks, coal-handling equipment, mechanical stokers, etc., it is principally a matter of the comparative cost of the two fuels. The field for oil fuel at present is among plants that are hand fired where there is a chance to make a considerable saving in labor. Later, after the Panama Canal is opened, there will be more oil. Then, he thought, the time would come when oil would compete with coal in large plants as well as small.

C. F. Dietz. (Written.) Mr. Collins suggests the possibility of a lower price for coal, should it become known that many plants were operate oil-fired boilers. On the other hand, after the plants had been equipped and oil consumption increased in any given district, there would be the danger of a rise in the price of oil, thus to a great extent balancing the advantages of the liquid fuel. This brings to mind an instance of one of the large European steamship companies which seriously considered the introduction of oil-fired boilers and equipped a vessel with a plant for trying out the scheme. This was some ten years ago. When it became known that oil-fired boilers were contemplated, the dealers from whom the company had been in the habit of buying their fuel promptly offered a reduction of a shilling per ton of coal. Advantage was promptly taken of this, with the result that the extensive experimental plant proved a decidedly good investment. During the operation of this steamer it was found that the temperatures developed in the fire box were very much higher than those usually obtaining in the coal-fired boilers, and led to many serious troubles which were gradually overcome by proper protection, as well as proper deflection of the oil blast. These difficulties have been practically done away with, so that oil-fired boilers no longer present this disadvantage.

The two principal methods used for atomizing the oil call either for steam or air and it would appear that the steam blast might have advantages over the air blast in the way of flame temperature, and the consequent effect upon the surfaces where the flame impinges

I am not aware of the existence of any data regarding the effect of the dissociation of the steam on the temperature of the flame, nor do I know whether the reverse action takes place almost immediately so that the heat taken up by the dissociation of the water is partly returned to the boiler as useful energy.

For the purpose of reviewing the chemistry and physics of the combustion more clearly, I present herewith the following calculations which seem to me to indicate clearly that the steam after dissociation must necessarily be burned back to water at a point in the boiler where the heat thus produced from the exothermic reaction is utilized.

Assuming $1\frac{1}{2}$ per cent of steam is used to atomize oil, then since, according to the tests, 15.4 lb. of water were evaporated per lb. of oil, it requires $15.4 \times 0.015 = 0.231$ lb. of steam to atomize 1 lb. of oil. The steam under the intense heat of the oil flame must be dissociated and requires 5806 B.t.u. per lb. of water, or $5806 \times 0.231 = 1341.186$ B.t.u. per lb. of oil is abstracted for dissociation of the steam.

Since the fuel has a given calorific value of 18,353 B.t.u., $\frac{1341.186}{18,353} = 7.3$ per cent of the fuel required to atomize the steam is needed to dissociate it. If this dissociation is normal under the temperature conditions, it is practically certain that a partial reaction at least must take place, otherwise the efficiency of the boiler as an absorber of heat could not be 81.1 per cent as given. It would be interesting to know to what extent the steam blast for atomizing the fuel chills the combustion chamber. Of course the temperature in the combustion chamber may be reduced at a sacrifice of boiler efficiency by allowing an increase in the quantity of excess air, everything else remaining equal. From purely theoretical considerations it would appear that the steam blast burner might have advantages over the air blast burner, at least in so far as the heat of combustion is concerned, if the dissociation of the steam takes place without an immediate reformation of water. I would suggest that in boiler tests using oil for fuel with both methods of atomizing, the flue gases be analyzed for free H. This can be done effectively with a Palladium tube.

That the temperature of combustion of fuel oil in a furnace is much higher than when coal is used is found in practice and borne out by the following rough calculation:

Composition of oil from Table 1 of Mr. Collins's paper is C, 83.3 per cent; H, 12.4 per cent; S, 0.5 per cent; and oxygen, 3.83 per cent. Assuming the excess air to be 15 per cent, then for combustion there is required per pound of oil

For C	2.080 lb. oxygen		
For H	0.992 lb. oxygen		
For S	0.005 lb. oxygen		
Total	3.077 lb. oxygen		
Less oxygen in oil	0.038 lb.		
Net oxygen required		3.039 lb.	
N with this oxygen		10.171 lb.	
Total air theoretical			13.210 lb.
15 per cent excess			1.980 lb.
Total air required			15.190 lb.

Products of combustion per pound of oil are then

			Per Cent by Weight
CO_2	2.080 + 0.833	= 2.913	18.00
H_2O	0.992 + 0.124	= 1.116	6.87
SO_2	0.005 + 0.005	= 0.010	0.06
O	0.455 (excess air)	= 0.455	2.82
N	10.171 + 1.525	= 11.696	72.30
		16.190	100.05

Assuming the analysis is made at 89 deg. fahr., the moisture in the gas can be only 3 per cent. At the temperature of the analysis gases are made up as follows:

	Per Cent by Weight	Per Cent by Volume
CO_2	18.700	13.22
H_2O	3.000	5.19
SO_2	0.062	0.0297
O	2.930	2.86
N	75.200	78.69
	99.892	99.9897

In these calculations the air for combustion has been considered dry. Comparing the above calculated analysis with that given in Table 2, we see that both the CO_2 and oxygen content check very closely, the average of all eight tests being 13.25 per cent CO_2 and 3.1 per cent oxygen, thus precluding the presence of any considerable quantity of free H, and the steam used for atomizing the oil cannot be considered a great robber of heat. It would be interesting to know where the reaction takes place. In this connection the difference between the most modern practice as given in this paper and that of 15 to 20 years ago may be noted.

W. S. Hutton in his Steam Boiler Construction makes the statement that "from 8 to 13 per cent of the total quantity of the steam produced by the boiler is expended in atomizing the oil, or converting it into spray." Under such conditions the high efficiencies now recorded could not be attained.

Further the same author says: "The minimum quantity of air that should be provided in practice is 22 lb. of air per lb. of oil, but it is generally necessary to provide a larger quantity than this, in order to prevent the production of smoke."

In the light of recent practice it becomes somewhat difficult to understand the reason for the above statement. However it is likely that the reasons for the heavy excess of air were due to conditions other than the chemistry of the combustion, and necessitated probably by the physical character of the fuel, the form of burner and fire box, size of combustion chamber, and other physical conditions which have since been improved upon to such an extent as to more nearly realize the theoretical requirements.

The conditions under which oil is burned produces a hotter fire than coal and accounts for the increase in capacity for any given boiler when changed over to oil, as well as for the difficulties experienced with boilers and fire boxes before it was realized that the direct flame gave rise to serious troubles. An idea of the temperature of combustion of the oil under the conditions discussed above may be gained from the following:

For each pound of oil burned there are liberated 18,353 heat units and a total of 16.2 lb. of gas are produced. The specific heat of this gas is probably not less than 0.3 on account of the high temperature and the presence of water vapor. The specific heat of furnace gases when coal is the fuel and 570 deg. fahr. the chimney temperature, has been found to be 0.265, but at the temperatures existing in the fire box the specific heats of the gases are very considerably higher. However, with an average of 0.3 we would have a maximum increase of temperature over the temperature of the air and oil of

$$16.2 \times 0.3 \times t = 18{,}353$$

$$t = 3776 + \text{(say) } 90 = 3866 \text{ deg. fahr.}$$

which while not actually realized in the combustion chamber, still leaves an actual existing temperature after deducting all losses, sufficiently high to make precautionary measures for the protection of the fire box and boiler of vital importance.

D. W. Robb held a point of comparison to be the cost of oil and coal. While oil is easier to handle, cleaner, etc., it is surprising what can be accomplished in burning coal, from the standpoint of economy, even by old-fashioned means. Mr. Robb had visited the "wood worsted" mill at South Lawrence, Mass., which is equipped with return tubular boilers and fired with soft coal. He found the temperature of the gas at the stack after passing through the economizers to be usually not over 200 deg. It leaves boilers at 375 to 380 deg. and the CO_2 present under these conditions is 13 to 14 per cent. This record is obtained by training the firemen under a good superintendent. They are not allowed to fire more than six or seven shovelfuls at a time, and are really not getting smoke.

The author had very properly pointed out that the question of oil burning is largely a question of the installation and management of the fires. The subject of oil burning is well worth the attention of large fuel users in New England, but they will want to know who is to control the price of the oil and whether a regular and sufficient supply can be depended upon. It will require careful investigation by engineers with results proved by actual tests to determine the economy.

E. F. Miller called attention to the high efficiency, around 80 per cent, shown in the tests quoted by the author, whereas in the case of boiler tests with coal as fuel he thought he himself had never secured over 70 per cent efficiency.

Robt. C. Monteagle referred to the steamships Harvard and Yale, now out on the Pacific coast, but formerly running between Boston and New York. They were first fitted to burn coal, but almost invariably required more than the 15 or 16 hours running time between the two cities. After running a year they were changed over to burn oil and had no difficulty in making their time. He also instanced the case of an explosion and fire on a vessel due to water in the oil which put out the flame, after which the oil kept flowing into the furnace. The fireman did not make his rounds properly, and when he discovered that the flame was out thrust his torch into the furnace.

J. C. Riley called attention to the fact that the flame from an oil burner is much like that from a blast lamp; its very high temperature is localized over so small an area that the metal of the boiler must be protected from it, whether the atomization is by steam or air. He had measured some temperatures in the furnaces of Scotch boilers with burners fired by both air and steam atomization. The furnaces were of the usual corrugated cylindrical type, opening into separate combustion chambers at the back. Each had a complete ring of fire-brick lining which extended about 4 ft. back, and another ring in front of and around the saddle seams where they entered the combustion chambers. There was also a layer of fire brick along the bottom, between the two rings, and one burner in each furnace, placed just above the axis and terminating about a foot back of the tube sheet.

On looking in at the front, the burner could be seen to spread the flame in a cone of about 80 deg. total angle, striking on the ring of brick. Apparently it was hottest right where it struck. With the steam burners, the flame was so dazzling that it was quite impossible to see beyond the surface of the cone. With the air burners clean and properly adjusted, the flame was yellower and not so bright; a little practice enabled one to see through the cone, even into the combustion chamber, and it appeared that the whole furnace was filled with a long, transparent yellow flame. With the air burners partially clogged with carbon, or not properly adjusted for air supply, the flame was irregular and smoky; drops of oil could be seen spattering on the furnace walls.

For measuring temperatures throughout the furnace and back into the combustion chamber, a distance of more than 10 ft., the ordinary form of porcelain-covered thermo-electric cane was out of the question, so a special form of water-cooled pyrometer was made. The outer tube was of 1-in. pipe, 12 ft. long. Inside was a ½-in. pipe to which water was pumped through a length of garden hose. The electric couple consisted of two wires of platinum and platinum-iridium, twisted together at one end and soldered to copper wire leads at the other. The twisted ends were inserted into a protecting tube of fused quartz. The leads were encased in a ¼-in. copper tube, 12 ft. long, which passed through the ½-in. pipe. The quartz tube passed through a water-tight stuffing box at the end of the 1-in. pipe, and projected about 4 in. into the fire. The joint between the copper and quartz was made tight with rubber tubing. The cold ends of the couple were thus inside the ½-in. pipe, where they were both at the same temperature, and this temperature was known within a very few degrees. The incoming water on leaving the ½-in. pipe passed back through the outer pipe and escaped through another hose. There was no difficulty in making the total rise in temperature of the water less than 25 deg.

It was found that with an air burner just cleaned and in best condition, the temperature throughout the furnace, from the burner back into the combustion chamber, was remarkably uniform, and that it averaged about 2250 deg. fahr. It was hottest at the axis of the furnace, a foot or two in front of the burner, and not where the cone of flame struck the brick lining. After several hours use without cleaning, the air burner gradually clogged with carbon until the mean temperature dropped to less than 1500 deg., in which case the front of the furnace was comparatively cool and the highest temperature was in the combustion chamber. The steam burner never clogged with carbon, but its temperature was not so uniformly distributed as that for air. In the axis of the furnace it dropped from more than 2400, just beyond the burner, to less than 2000 in the combustion chamber. It was extremely hot where the cone of flame struck the brick along the bottom; one observation gave more than 2500 deg., a temperature which destroyed a quartz tube of the pyrometer.

The necessity for protecting the metal of a boiler from direct contact with the hottest point of flame is apparent to any one who has seen the flame marks which are sometimes burned in by careless firing. Burning of the steel is most likely to occur when the oil fuel contains much sulphur. It is also likely to occur when for any reason the rate of heat conduction is slow or the circulation is not active.

For burning oil it is especially desirable that the fireman should be a man of intelligence and good judgment. A few minutes of neglect or carelessness may injure the boiler seriously. When everything is operating well and the burners properly adjusted, a slug of water may come along with the fuel and put the flame out. To be sure it ought not be there, for the suction pipe of the fuel pump is floated near the surface of the oil in the supply tank, to guard particularly against this happening. But sometimes the thing which cannot happen does occur, and the flame goes out. Then when the next oil passes the burner, if there are other burners still lighted in the same furnace, or if the brick target is still hot enough to ignite the oil instantly upon contact, no harm is done; but if the oil does not light, and if the fireman does not notice the fact, there is great danger of an explosion, or at least a fire.

B. R. T. Collins, in reply to the inquiry as to what percentage of the steam produced by the boilers is required for the jet apparatus and pumps, said it varies from a little less than 1½ to 2 per cent for atomizing in the burners and for operating small oil pumps it takes an equal quantity, or from 3 to 4 per cent in all. Using air to atomize requires about the same amount of steam to operate the air compressors.

In reply, also, to an inquiry as to the relative loss in firing coal by hand and in using oil without automatic regulators, he believed that whereas with coal a poor fireman could make a difference of 10 to 15 per cent it would not be more than half this with poor oil firing.

Answering Mr. Monteagle with regard to water in oil, he said he had burned fuel oil or residuum, at Dallas, Texas, all summer and there was no water at all in it, all the moisture having been driven off by the process of partial distillation through which it had passed. In California there is considerable water in the oil because crude oil direct from the wells is burned almost entirely. In such cases, tests are made of the oil after delivery and contracts so worded that if the water exceeds 1 per cent there will be a rebate for all over that amount.

In the vessel spoken of by Mr. Monteagle, the fireman should have determined whether there was any gas or unburned oil in the furnace before applying the torch. This is why so much stress should be laid on having intelligent firemen.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(VIII)

ARTICLES IN PERIODICALS[1]

Back Firing and Fuel Water in a Large Producer Gas Engine Plant, Correcting, J. G. Callan. *Power, July 11, 1911.* 1 p. *bc.*

Abstract of paper presented before the Congress of Technology, Massachusetts Institute of Technology, Boston.

Fire Pump, Petrol-Driven. *The Engineer (London), June 23, 1911.* ⅛ p., 1 fig. *bfB.*

Of interest in that it is supposedly the largest in the world. Capacity, 800 gal. per min. at 225 r.p.m. at high pressure; 4 vertical cylinders; 80 h.p.

Generatorgasanlage, Versuche an einer, Kurt Neumann. *Zeitschrift des Vereines Deutscher Ingenieure, June 3, 1911.* 5 pp., 1 fig., 2 tables, 5 curves. *bce.*

Tests of a producer gas plant.

Küppers Gas Producer, The. *The Iron Age, June 22, 1911.* 1½ pp., 3 figs., 1 table. *bc.*

A German producer with revolving grate and revolving shaft.

Moteur à Gas. *Revue de Mécanique, May 31, 1911.* 8 pp., 27 figs., 1 table. *B.*

Description and detail drawings of the following types of gasolene motors; details of cylinder—Neustadter, Ehrhardt and Schmer, Knight and Kilbourne motor (1905), Knight motor (1908), Riley motor (1908), White motor (1908), Lanchester motor (1909). Sears motor, Mether and Platt motor, (1908).

Oil Engine Practice, Developments in. *The Gas Engine, June 1911* 2½ pp. *adfB.*

Extract of paper read before the Institute of Marine Engineers by Mr. Shacketon.

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[1] Opinions expressed are those of the reviewer not of the Society. Articles are classified as *a* comparative; *b* descriptive; *c* experimental; *d* historical; *e* mathematical; *f* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

OIL GAS PRODUCER, AN. *The Iron Age, July 13, 1911.* 2 pp., 3 figs. *bf.*

Description and details of the International-Amet Gas Power Company's oil gas producer.

PETROL AND OIL TRACTORS AT THE NORWICH (ENGLAND) SHOW. *London Engineering, June 30, 1911.* 6 pp., 14 figs. *bf.*

Describes 30-h.p. and 100-h.p. petrol tractor and 90-h.p. oil tractor.

PRODUCERS, GAS, W. A. Tookey. *The Gas Engine, June 1911.* 9 pp., 4 figs. *abdfA.*

Extracts of paper before the British Association of Engineers-in-Charge.

PRODUCER GAS, FORMATION OF, J. K. Clement, L. H. Adams and C. N. Haskins. *The Gas Engine, June 1911.* 1½ pp. *bcefB.*

Extract of Bull. No. 7, Bureau of Mines, Essential Factors in the Formation of Producer Gas.

PRODUCER GAS FROM CRUDE OIL, F. C. Jones. *The Gas Engine, June 1911.* 1½ pp., 3 tables. *bfC.*

Gives data and description of producer.

PUMPING PLANT USING PRODUCER GAS, A MUNICIPAL. *The Gas Engine, June 1911.* 2½ pp. *bfC.*

Extract of report by R. C. Allen, The Equipment of the New Gravel Pond Station, Manchester, Mass., including data.

SCHÜRLOCHVERSCHLÜSSE FÜR GASERZEUGER, L. FRICK. *Stahl und Eisen, June 15, 1911.* 3 pp., 6 figs. *bf.*

An article on poke-hole closures in gas generators.

STATIONS CENTRALES, CONDITIONS ÉCONOMIQUES D'ETABLISSEMENT PETITES, A. R. Garnier. *L'Industrie Électrique, May 25, 1911.* 6 pp., 2 figs., 6 tables *abef.*

A continued article on the establishment of small central stations. Includes information data, etc., on motors, gas engines, and fuels.

VERWENDUNG DER GASE IN EISENHÜTTEN UND KOKEREIEN, NEUERE BESTREBUNG IN DER, Fritz W. Lürmann. *Stahl und Eisen, June 8, 1911.* 9 pp., 15 tables. *bf.*

An article on later efforts toward the use of blast furnace and coke oven gases.

GENERAL NOTES

AMERICAN INSTITUTE OF MINING ENGINEERS

The 101st meeting of the American Institute of Mining Engineers will be held in San Francisco, commencing October 10, 1911, in the St. Francis Hotel. Technical sessions will occupy the afternoons of Tuesday, Wednesday morning and afternoon, and Thursday morning, when the party will go by special train to Bakersfield, arriving early Friday morning, for a visit to the various oil fields. On Friday night, the party will proceed by train to the heart of the gold-dredging district, near Folsom, spending the day in visits to the gold dredges and the great rock-crushing plant of the Natomas Consolidated Company. On Saturday afternoon a public reception will be held in the State Capitol, and the party will proceed by train through Napa and Sonoma valleys, arriving at the Bohemian Club amphitheatre on Sunday morning, where a barbecue luncheon will be held, and where the entire day will be spent. On Sunday evening, the party will return to San Francisco.

This meeting will be followed by an excursion to Japan, sailing from San Francisco on October 17, stopping at Honolulu, and reaching Yokohama November 3, in time to see the parade in honor of the Emperor's birthday. The excursion through Japan covers the chief points of historic, scenic and professional interest. The return trip will start from Yokohama, November 21, reaching San Francisco, December 7.

AMERICAN SOCIETY FOR TESTING MATERIALS

The fourteenth annual convention of the American Society of Testing Materials was held at the Hotel Traymore, Atlantic City, N. J., June 27–July 1, 1911, with an attendance of over 400. Dr. Henry M. Howe delivered the annual address. One of the important features of the meeting was the presentation of reports from various committees, including that of the Committee on Preservation of Coatings, on Standard Tests for Road Materials, Standard Specifications for Steel, etc. Among the papers presented were, Practical Testing of Drying and Semi-Drying Paint Oils, by Henry A. Gardner; Novel Method of Detecting Mineral Oil and Resin Oil in Other Oils, by A. E. Outerbridge, Jr.; Practical Tests of Sand and Gravel Proposed for Use in Concrete, R. S. Greenman; Some Experiments on the Incrustation and Absorption of Concrete, A. O. Anderson; Apparatus for Determining Drop Point and Softening Point of Compounds, H. W. Fisher; Methods for Testing Sewer Pipe and Drain Pipe, A. Marston; Manufacturing of Pure Irons in Open-Hearth Furnaces, A. S. Cushman; Hardness Tests, Bradley Stoughton and J. S. McGregor; The Property of Hardness in Metals and Materials, A. F. Shore; and Behavior of Cast Zinc under Compression, J. C. Trautwine, Jr.

THE INSTITUTION OF MECHANICAL ENGINEERS

The summer meeting of the Institution of Mechanical Engineers was held in Zürich and Northern Switzerland, commencing on July 24 and closing on the 27th. The program as announced included a number of technical excursions, as well as trips of more general interest, and the following papers to be presented at the technical sessions: Results of Experiments with Francis Turbines and Tangential (Pelton) Turbines, Dr. Franz Prásil; Some New Types of Dynamometers, Dr. Alfred Amsler; Railway Electrification in Switzerland, Emil Huber; Hydraulic Power Works and their Construction, with Special Reference to the Difficulties Encountered and the Methods of Overcoming Them, I. Zodel; Steam Turbines, H. Zoelly; Diesel Oil Engines, Jacob Sulzer; and Rack Locomotives of Switzerland, Mr. Pfander.

AMERICAN CHEMICAL SOCIETY

Among the papers presented before the division of Industrial Chemists and Chemical Engineers of the American Chemical Society at the annual meeting in Indianapolis, Ind., June 28–July 1, were the following: Losses in the Storage of Coal, H. C. Porter, F. K. Ovitz; Need of a Professional Code of Ethics among Chemists, F. L. Parker, Jr.; Storage Battery Efficiency, J. S. Staudt; A New Modification of Gas Analysis Apparatus, B. G. Klugh; Refractories and Laboratory Appliances Made from Alundum, P. A. Boeck; Determination of Vanadium in Vanadium and Chrome-Vanadium Steels, J. R. Cain; Determination of Dust in Blast Furnace Gas, L. A. Touzalin; The Wood Distillation Industry of the Pacific Northwest, H. K. Benson; Ratfish Oil as a Paint Material, H. K. Benson, W. Eshleman; A Method of Analysis of Lead Ores, J. Waddell; Concentration and Purification of Iron Ore, High in Sulphur by Roasting in a Rotary Kiln.

INTERNATIONAL ASSOCIATION FOR THE PREVENTION OF SMOKE

At the annual convention of the International Association for the Prevention of Smoke held in Newark, N. J., June 28–30, the following papers were presented: Enforcement of the Smoke Prevention Ordinance in New York City, E. J. Lederle; Smoke Prevention in Large Power Stations, J. T. Whittlesey and H. S. Vasser. R. H. Fernald, Mem. Am. Soc. M. E., gave an illustrated lecture on The Relation of the Gas Producer to the Smoke Problem and R. B. Watrous lectured on Smoke Versus City Beauty. The problem of the Prevention of Smoke on Railways was discussed by C. D. Young, F. T. Howley and J. P. Brown.

PERSONALS

N. B. Ayers has resigned the position of chief engineer of the Dayton Power & Light Co., Dayton, O., to organize the Ayers Engineering Co., Dayton, O., for handling power plant engineering.

Charles L. Clarke has become associated with the General Electric Co., New York.

Alexander Dow received the honorary degree of Doctor of Engineering from the University of Michigan during the commencement exercises at Ann Arbor, June 29.

H. J. Freyn has become associated with the Allis-Chalmers Co., West Allis, Wis. He was until recently assistant engineer of construction of the Illinois Steel Co., South Chicago, Ill.

Geo. W. Fuller has associated with him as partners Jas. W. Armstrong, Jas. C. Harding and Jas. R. McClintock, all formerly of the staff of Hering & Fuller, New York.

Edwin S. Harrison, formerly sales engineer of the Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo., has been appointed resident engineer of the new plant of the Bucyrus-Vulcan Co., Evansville, Ind.

Rudolph Hering and John H. Gregory have formed a partnership as consulting engineers and sanitary experts, with offices in New York.

Fritz A. Lindberg has been made a member of the firm of Brill & Gardner, Chicago, Ill. Mr. Lindberg was formerly associated with the company as assistant engineer.

Tracy Lyon, until recently associated with the Westinghouse Electric & Manufacturing Co., Pittsburg, Pa., as assistant to first vice-president, has become connected with the General Motors Co., Detroit, Mich.

J. E. Powell, chief mechanical and electrical engineer in the office of the supervising architect, Treasury Department, Washington, D. C., has resigned on account of ill health.

E. Burton Smith has been appointed superintendent of the Toledo Lamp Works of the General Electric Co., Toledo, O. He was formerly associated with the Harrison, N. J., branch of this company.

Alan G. Williams has assumed the duties of engine house foreman of the Vandalia Railroad, Terre Haute, Ind. He was formerly general foreman of the Pennsylvania Railroad shop at Buffalo, N. Y.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary, Am.Soc.M.E.

ADDRESS OF ALEX. C. HUMPHREYS, DELIVERED AT THE ANNUAL DINNER OF THE ALUMNI OF STEVENS INSTITUTE OF TECHNOLOGY, Feb. 4, 1908. Gift of C. W. Rice.

AMERICAN INSTITUTE OF ARCHITECTS. Annuary, 1910. Gift of the Institute.

AMERICAN RAILWAY ASSOCIATION. Proceedings of session held in New York City, May 17, 1911. Gift of the association.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. The Journal. Vol. 33, Nos. 1-6. *New York, 1911.*

ANALYSIS OF PAINTS AND PAINTING MATERIALS. By H. A. Gardner and J. A. Schaeffer. *New York, McGraw-Hill Book Co., 1911.*

A book for chemists, but one of interest to mechanical engineers, because so little has been published on protective paints. It gives methods for the analysis of dry and mixed paints, paint vehicles and varnishes, and bituminous paints. In an appendix is reprinted the specifications of the Army and Navy Departments. Index.

ARMY LIST AND DIRECTORY. Officers of the Army of the United States, June 20, 1911. *Washington, 1911.* Gift of Superintendent of Documents.

BROADENING THE FIELD OF THE MARINE STEAM TURBINE: THE PROBLEM AND ITS SOLUTION. The Melville and Macalpine Reduction Gear. *Pittsburg, 1909.* Gift of C. W. Rice.

A BUSY WEEK. Andrew Carnegie at Dunfermline, Kirkcaldy, Dumfries, Portmahomack. *Dunfermline, 1899.* Gift of C. W. Rice.

CATSKILL MOUNTAINS WATER WORKS FOR THE EXTENSION OF THE WATER SUPPLY OF NEW YORK CITY, December 1910. *Pittsburgh, 1911.* Gift of Blaw Collapsible Steel Centering Co.

COMBUSTION AND THE COST OF POWER. (Bulletin No. 100, Uehling Instrument Co.). *Passaic.* Gift of Uehling Instrument Co.

COMPARISON OF UNIVERSITY AND INDUSTRIAL METHODS AND DISCIPLINE. By F. W. Taylor. Gift of C. W. Rice.

DELAWARE COLLEGE, NEWARK, DEL. Catalogue, 1911. *Newark, 1911.* Gift of Delaware College.

DUDLEY, CHARLES B., MEMORIAL VOLUME COMMEMORATIVE OF THE LIFE AND LIFE-WORK OF, 1842-1909. *Philadelphia.*

ENTROPY: OR THERMODYNAMICS FROM AN ENGINEER'S STANDPOINT, AND THE REVERSIBILITY OF THERMODYNAMICS. By James Swinburne. *New York, E. P. Dutton Co., 1903.*

General Contract and Specifications for the Purchase of Coal, State of Wisconsin Capitol Power and Heating Plant. By J. C. White. *Madison, 1911.* Gift of the author.

Handbook for Iron Founders. *London.* Gift of Frodair Iron & Steel Co. Ltd.

High Speed Steel. By O. M. Becker. *New York, McGraw-Hill Book Co., 1910.*

Internal Combustion Engines at the Brussels Exposition. By P. R. Allen. Reprinted from Cassier's Magazine, February-March 1911. Gift of author.

Johns Hopkins University. Register 1910-1911. *Baltimore, 1911.* Gift of the University.

Leland Stanford Junior University. Register, 1910-1911. *California, 1911.*

——Department of Medicine. Annual Announcement, 1911-1912. *California, 1911.* Gift of the University.

Louisiana State University. Catalogue, 1911. *Baton Rouge, 1911.* Gift of the University.

Marine Engine Design. By E. M. Bragg. *New York, D. Van Nostrand Co. 1911.*

A reprint of articles first published in International Marine Engineering, developed from several years of experience in teaching the subject to students of the University of Michigan. It is totally free from the descriptive part of the subject, confining itself to the laying out and designing of the engine. In this particular it differs from other works on the subject. No index, but a table of contents.

Metropolitan Water and Sewerage Board. Tenth Annual Report, 1911. *Boston, 1911.* Gift of Metropolitan Water and Sewerage Board.

More Busy Days. Andrew Carnegie at Dingwall, Tain, Kilmarnock, Govan, Waterford, Limerick, Cork, Barrow in 1903. *Philadelphia, 1903.* Gift of C. W. Rice.

Pacific Gas and Electric Company. Properties owned and operated territory served. *California, 1911.* Gift of Pacific Gas and Electric Co.

Pennsylvania State Railroad Commission in the Matter of the Complaints against the Philadelphia Rapid Transit Company. Report. Vols. 1-2, 1911. *New York, 1911.* Gift of Messrs. Ford, Bacon and Davis.

Polytechnic Institute of Brooklyn. Catalogue of the College of Engineering, 1911-1912. *Brooklyn.* Gift of the Institute.

Principles of Industrial Engineering. By C. B. Going. *New York, McGraw-Hill Book Co., 1911.*

This work is based on a series of lectures delivered to the senior students in the department of engineering at Columbia. The study is directed almost wholly to the discovery and definition of ideals and principles, or in some cases of institutions; very little attempt is made at the description of methods and devices. It thus supplements the works of Gantt, Emerson, Taylor and others. An entertaining book even for a layman.

Pumping Machinery. By A. M. Greene. *New York, J. Wiley & Sons, 1911.*

This book is based on a series of lectures given as a required course to the mechanical engineering students of the University of Missouri. The bibliography of thirteen pages is especially valuable, in that it includes references to the original accounts of tests of pumps. Many of these tests are given in the main text. The work seems very comprehensive, both on the theoretical and descriptive side. It is profusely illustrated, and adequately indexed.

RELATIVE TO THE ELECTRIFICATION OF RAILROADS, STATEMENT OF GEO. F. SWAIN, BEFORE THE METROPOLITAN AFFAIRS AND RAILROAD COMMITTEES OF THE MASSACHUSETTS LEGISLATURE. April 6, 1911. Gift of author.

TEXAS AGRICULTURAL AND MECHANICAL COLLEGE. Thirty-fifth Annual Catalogue, 1910-1911. *Austin, 1911.*

——Announcement of the Third Session of the summer school, 1911. *Austin, 1911.* Gift of the Texas Agricultural and Mechanical College.

THREE BUSY WEEKS. Andrew Carnegie at Perth, Edinburgh, Greenock, Falkirk, Stirling, Hawarden, Liverpool, St. Andrews, Dundee. *Dunfermline, 1902.* Gift of C. W. Rice.

UNIVERSITY OF TORONTO. Calendar, 1911-1912. *Toronto.* Gift of the University.

UNIVERSITY OF UTAH. Catalogue, 1911-1912. *Salt Lake City, 1911.* Gift of the University.

VERZEICHNIS DER DEUTSCHEN PATENTKLASSEN UND IHRE EINTEILUNG IN UNTERKLASSEN UND GRUPPEN. ed. 2. *Berlin, 1910.*

VICTORIAN INSTITUTE OF ENGINEERS. Proceedings, Vol. 11. *Melbourne, 1911.* Gift of the Institute.

WENTWORTH INSTITUTE. Catalogue. 1911-1912. *Boston, 1911.* Gift of the Institute.

WESTINGHOUSE MARINE STEAM TURBINE WITH MELVILLE AND MACALPINE REDUCTION GEAR. Gift of C. W. Rice.

WHITTAKER'S ELECTRICAL ENGINEER'S POCKET BOOK. ed. 3. Edited by Kenelm Edgecumbe. *London, 1911.* Gift of Macmillan Co.

This is the third edition of this well known English pocket book, largely rewritten to bring it up to date. It has an extremely useful index, differing in this particular from many English technical works.

EXCHANGES

AMERICAN SOCIETY OF CIVIL ENGINEERS. *Transactions.* Vol. 72, 1911. *New York, 1911.*

SMITHSONIAN PHYSICAL TABLES. ed. 5, revised. (Miscellaneous collections, Vol. 58, No. 1.) *Washington, 1910.*

SOCIETY OF AUTOMOBILE ENGINEERS. Handbook (data sheets), 1911. *New York, 1911.*

TRADE CATALOGUES

AMERICAN SPIRAL PIPE WORKS, *Chicago, Ill.* Spiral riveted pipe, leg welded steel pipe, forged steel pipe flanges, hydraulic and exhaust steam supplies. 20 pp.

J. T. BAKER CHEMICAL CO., *Philippsburg, N. J.* The Chemist-Analyst, No. 2. 24 pp.

THE BRISTOL CO., *Waterbury, Conn.* Bull. No. 131, Recording voltmeter for direct and alternating current, 43 pp.; Bull. No. 147A, Bristol-Durand radii averaging instrument for circular chart records, 7 pp.

Consolidated Expanded Metal Co., *Pittsburg, Pa.* Handbook of design, containing tables, standards and useful information on reinforced concrete. 102 pp.

Green Fuel Economizer Co., *Matteawan, N. Y.* Planing mill exhausters. 20 pp.

Max Henning, *Berlin, Germany.* Addresses of commercial firms. 32 pp.

Hess-Bright Mfg. Co., *Philadelphia, Pa.* Ball bearings in flour and feed mill machinery, 19 pp.; Ball bearings in wood-working machinery, 29 pp

Fred. S. Hinds, *Boston, Mass.* Industrial plants. 76 pp.

A. L. Ide & Sons, *Springfield, Ill.* Bull. 17, Simple side crank "Ideal" engine direct-connected to generator. 10 pp.

Ideal Electric & Mfg. Co., *Mansfield, O.* Reducing expenses and increasing output of textile mills. 7 pp.

H. W. Johns-Manville Co., *Cleveland, O.* J. M. Packing Expert, June 1911. 8 pp. J. M. Roofing Salesman, June 1911. 8 pp.

Link-Belt Co., *Chicago, Ill.* Price list of flint-rim sprocket and traction wheels. 20 pp.

Niles-Bement-Pond Co., *Cleveland, O.* Aurora drills. 32 pp.

Robt. W. Paul, *London, England.* Electrical measuring instruments. 32 pp.

Pulsometer Steam Pump Co., *New York.* The pulsometer. 27 pp.

Rockwell Furnace Co., *New York.* Moyer tramrail in foundry practice. 8 pp.

Russell, Birdsall & Ward, *Port Chester, N. Y.* Bolts and nuts. 160 pp.

Stephens-Adamson Co., *Aurora, Ill.* The Labor Saver, June 1911. 25 pp.

Tate, Jones & Co., *Pittsburg, Pa.* Furnaces for annealing, hardening and tempering. 28 pp.

Vulcan Soot Cleaner Co. of Pittsburg, Pa. *Du Bois, Pa.* Soot cleaners. 32 pp.

Wilson-Maeulen Co., *New York.* Electric pyrometers. 12 pp. Melting points of the elements, 1 p., Conversion table for centigrade to fahrenheit and vice versa, 1 p.

UNITED ENGINEERING SOCIETY

Davis Handbook of the Porcupine Gold District. By H. P. Davis. *New York, 1911.* Gift of author.

New Method Calculating the Cubic Contents of Excavations and Embankments, by the Aid of Diagrams. ed. 4. By J. C. Trautwine. *Philadelphia, 1871.*

Patente-Jahres, Katalog 22, Jahrgang 1910. *Brugg, 1911.*

EMPLOYMENT BULLETIN

The Society has always considered it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for notices in this Bulletin should be received before the 12th of the month. The list of men available is made up of members of the Society and these are on file, with the names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0109 Engineer of wide experience wishes to become associated with man of means with view to manufacturing on small scale and taking small contracts. Two small articles, one patented, other in course of preparation for patent office.

0110 Instructorship in mechanical engineering at State University of Iowa paying $1400 to person of proper experience and attainment. For particulars address William G. Raymond, Iowa City, Iowa.

0111 Man to assist in the building and development of automatic weighing machines, can machines, etc. Small machine shop employing 18 men at the present time. Requires a man capable of making drawings, following through the pattern and machine shops, and coöperating with the machine shop foreman in executing work. Location Illinois.

MEN AVAILABLE

250 Superintendent of machine shops, foundries, etc. Extensive experience in the building of heavy engines, air compressors, pumps, conveying and power transmission machinery.

251 Junior member, technical graduate, several years' experience as draftsman, also experience in construction and in office work, power plant and industrial plant installations.

252 Mechanical and electrical engineer, technical graduate, practical shop experience, eight years in general engineering and manufacturing; designing, construction and executive experience; desires position as executive engineer with manufacturing concern or chief engineer with engineering or contracting firm.

253 Graduate mechanical engineer, six years' experience, designing and drafting, but mainly in research and experimental work along lines connected with steam engineering. At present employed, desires change with view to bettering condition. Best of references.

254 Member, technical education, civil and mechanical engineer, desires position by September 1. Last fifteen years chief mechanical engineer in responsible charge. Ability as business builder, designed and built special tools, air compressors, high duty pumping engines, electric cranes, compressed air cranes and other machinery, Corliss, high-speed and automatic engines, experience in selling, familiar with contracts, shop management and economical and systematic design of machines. Excellent references as to character and ability.

255 Technical graduate, four years' experience in all phases of plant engineering, cost reduction, accounting, tool systems, power plant operations construction and maintenance, with extensive study of scientific management and accounting. Thoroughly accustomed to handling men and working on own responsibility. Now employed.

256 Graduate Mass. Institute Technology, age 27, two years' experience in building construction and mechanical equipment, desires connection with architect or contracting engineer where there is opportunity for advancement. Salary expected, $25 a week.

257 Mechanical engineer will undertake development or extension of product of manufacturing company; experienced in engineering and physical research, formerly in charge of design and construction of internal combustion engines, small and large, gas producers, and power stations.

258 Member prepared to go into partnership or associate with manufacturing concern; desires interest in the business instead of salary. Equipped with all-round research and manufacturing experience in electrical and mechanical work.

259 Superintendent desires position in New York or vicinity; age 37; experienced machinist and shop foreman, including tool, die, fig, patternmaking, switchboard apparatus and miscellaneous electrical supplies. Competent to organize and take charge of production department.

260 Teacher of mechanical drawing and machine design, age 33, technical graduate with four years' drafting room and four years' teaching experience, seeks appointment.

261 Mechanical engineer, 12 years' experience; shop, sales and executive. Specialties conveying and elevating machinery, constructive work. Desires position as manager or chief engineer.

CHANGES IN MEMBERSHIP

CHANGES IN ADDRESS

ALDRICH, William Sleeper (1892), Life Member; Powell, Wyo.

ALLISON, John Franklin (Junior, 1910), 459 Martin St., Roxborough, Philadelphia, Pa.

AYERS. Norwood B. (1908), The Ayers Engrg. Co., Conover Bldg., and 422 Summers St., Dayton, O.

BIBBINS, James Rowland (1904;1909), Engr. with Bion J. Arnold, Rm. 1000, 105 S. La Salle St., Chicago, Ill.

BAILEY, Hazil Harding (Junior, 1910), Packard Motor Car Co., and *for mail*, 1453 Grand Blvd., E., Detroit, Mich.

BAUER, Chas. L. (1900;1901) Pres., The Bauer Bros. Co., and 1215 E. High St., Springfield, O.

BAYLIS, Arthur Raymond (1905;1906), N. E. Engrg. Co., 50 Church St., New York, and *for mail*, 1815 Ave. K, Flatbush, Brooklyn, N. Y.

CHAMBERS, Norman C. (Junior, 1905), Export Dept., Niles-Bement-Pond Co., 111 Broadway, New York, N. Y., and *for mail*, care of A. Cazzani, Boite Postale, 802, Rio de Janeiro, Brazil, S. A.

CHAPMAN, Frank T. (1909), Rep., Vento Dept., Am. Radiator Co., Rm. 501, 104 W. 42d St., New York, N. Y., and Montclair, N. J.

CHESTER, C. P. (Associate, 1908), Stone and Webster Engrg. Corp., Burleson, Tex.

CLARKE, Charles L. (1882), Genl. Elec. Co., Rm. 1923, 30 Church St., New York, N. Y.

CUMMINGS, Wm. Warren (1905), Cons. and Contr. Engr., Hanover, N. H.

CUNNINGHAM, Geo. H. (Junior, 1911), Consolidation Coal Co., Jenkins, Ky.

DANFORTH, Albert W. (1882), 881 Bridge St., Lowell, Mass.

DARRIN, David H. (1892;1900), Cons. Engr., 131 Liberty St., and Engrs. Club, 32 W. 40th St., New York, N. Y.

DIETZ, Carl F. (1903;1910), Cons. Engr., Dietz & Keedy, 6 Beacon St., Boston, and *for mail*, 214 Lynn Fells Parkway, Melrose, Mass.

DOUD, Arthur T. (Junior, 1907), Genl. Supt., Speakman Supply & Pipe Co., and 1320 Clayton St., Wilmington, Del.

EDWARDS, William J. (1910), V. P. and Treas., Binghamton Clothing Co., and *for mail*, 31 Stuyvesant St., Binghamton, N. Y.

FREYN, Heinrich Josef Karl (1906), Allis-Chalmers Co., West Allis, and 254 Mason St., Milwaukee, Wis.

FULLER, George W. (1910), Cons. Engr., 170 Broadway, New York, N. Y.

GOENTNER, William B. (Junior, 1905), Asst. Engr., Dept. of Water Supply, Gas and Elec., 13-21 Park Row, and *for mail*, 2020 Park Row Bldg., New York, N. Y.

JACKSON, Dugald C. (1890), Mass. Inst. of Tech., Boston, Mass., and D. C. & Wm. B. Jackson, 111 W. Monroe St., Chicago, Ill.

JACKSON, Wm. B. (1901), Life Member; D. C. & Wm. B. Jackson, Harris Trust Bldg., 111 Monroe St., and 5526 Everett Ave., Chicago, Ill.

LEWIS, Joseph E. (Junior, 1899), Treas., Bush Mfg. Co., Hartford, Conn., and *for mail*, Centerville, Cape Cod, Mass.

LINCH, Edward P. (1902), P.O. Box 612, Waterbury, Conn.

LINDBERG, Fritz A. (1908; 1911), Member of Firm, Brill & Gardner, 1135 Marquette Bldg., and *for mail*, 514 E. 62d St., Chicago, Ill.

LOWE, Henry Leland (Junior, 1903), 280 Downey Ave., Indianapolis, Ind.

LYON, Tracy (1893), Genl. Motors Co., Detroit, Mich.

HAMILTON, Chester B., Jr., (Junior, 1909), Mgr., The Hamilton Gear and Machine Co., and *for mail*, 43 Madison Ave., Toronto, Canada.

HARRISON, Edwin S. (Junior, 1905), Res. Engr., Bucyrus-Vulcan Co., and *for mail*, P. O. Box 201, Evansville, Ind.

HAYES, Frank H. (1906), N. E. Mgr., Platt Iron Wks. Co., 101 High St., Boston, and *for mail*, 13 Willow Ave., West Somerville, Mass.

HERING, Rudolph (1906), Life Member; Cons. Engr., Hering & Gregory, 170 Broadway, New York, N. Y., and 40 Lloyd Rd., Montclair, N. J.

HUTCHINSON, Charles Tripler (1910), Mgr., Min. Mchy. Dept., Joshua Hendy Iron Wks., 75 Fremont St., San Francisco, Cal.

McCLINTOCK, Edward H. (1901; 1905), Constr. Engr. and Mill Arch., 33 Lyman St., Springfield, and 71 Pearson Ave., West Somerville, Mass.

McDEWELL, Horatio S. (Junior, 1908), 94 Addington Rd., Brookline, Mass.

MacGREGOR, Walter (1906), 3118 W. 19th St., Chicago, Ill.

MARKS, Harry J. (1907), Mech. Engr., 90 West St., New York, and *for mail*, 86 Palmer Ave., Mamaroneck, N. Y.

MAROT, Edward H. (Junior, 1903), 38 Pastorius St., Germantown, Philadelphia, Pa.

NEWTON, Lewis W. (1903), Engr., 412 Main St., Amesbury, Mass.

NILES, Francis H. (Associate, 1907), Dongannas Farms, Rock Castle P. O., Va.

ORCUTT, Guy H. (Junior, 1909), Testing Engr., Allis-Chalmers Co., and *for mail*, 910 E. 62d St., Chicago, Ill.

PEARSON, Walter Ambrose (1907), Asst. Genl. Mgr., Rio de Janeiro Tramway, Light & Power Co., Ltd., Caixa 571, Rio de Janeiro, Brazil, S. A., and *for mail*, 25 Broad St., New York, N. Y.

PINGER, George C. (Junior, 1907), Beaver, Pa.

RAPLEY, Frederick Harvey (1905), M. Clark & Co., 1 Victoria St., Westminster, S. W., London, England.

RICHARDSON, Levi S. (1909), Ch. Draftsman, Lehner Engrg. Co., 149 Broadway, New York, and *for mail*, 134 Pelton Ave., West New Brighton, S. I., N. Y.

RICKETTS Edwin Burnley (Junior, 1908), U. S. Glass Co., Glassport, Pa.

ROGERS, Robert W. (Junior, 1908), 5 Dey St., New York, N. Y.

SANGUINETTI, Philip C. (Associate, 1909), Production Engrg. Dept., Marwick, Mitchell & Co., 79 Wall St., New York, and 265 S. 1st Ave., Mt. Vernon, N. Y.

SCHAEFFLER, Joseph C. (1900; 1904; 1907), Mech. and Civ. Engr., Joseph C. Schaeffler & Co., Archs. and Engrs., 38-40 W. 32d St., New York, N. Y.

SCOTT, Arthur Curtis (1908), Pres., The Scott Engrg. Co., 632 Wilson Bldg., Dallas, Tex.

SMITH, Ellis Burton (Junior, 1905), Supt. Toledo Lamp Wks., Genl. Elec. Co., Toledo, O.

SMITH, W. W. (1909), Mech. Engr., 460 E. Adams St., Los Angeles, Cal.

SPENCER, William J. (Junior, 1906), 5116 N. 11th St., Philadelphia, Pa.

STOCKWELL, Rupert Kennedy (Junior, 1910), Mech. Engr., The Tenn. Copper Co., Copperhill, Tenn.

TAYLOR, Wyatt W. (Associate, 1908), Cons. Engr., 2 Rector St., New York, and *for mail*, Spuyten Duyvil, N. Y.

TORRANCE, Henry, Jr. (1897; 1902), V. P. and Treas., Carbondale Mch. Co., 50 Church St., New York, N. Y., and Tenafly, N. J.

WENTWORTH, Reginald Andrew (Junior, 1911), Engineer with H. L. Gantt, and *for mail*, 2045 N. 63d St., Philadelphia, Pa.

WERST, Charles Wm. (1909), Supt., Lima Loco. & Mch. Co., and *for mail*, 1534 Lakewood Ave., Lima, O.

WHITESIDE, Walter Hunter (1910), Stevens-Duryea Co., Chicopee Falls, Mass.

WILEY, James M. (Junior, 1909), Swink, Colo.

WILLIAMS, Alan Gillespie (Junior, 1909), Eng. House Foreman, Vandalia R. R., and *for mail*, 672 Eagle St., Terre Haute, Ind.

NEW MEMBERS

ALBERT, Calvin D. (1911), Asst. Prof. Mch. Design, Sibley College, Cornell Univ., and 319 Eddy St., Ithaca, N. Y.

ANDREI, Camillo (Junior, 1911), Società Nazionale dei Radiatori, Borgo S. Giovanni, Brescia, Italy.

BRIGGS, Leroy Edmund (Junior, 1911), 235 Vine St., Bridgeport, Conn.

CLAYTON, J. Paul (Junior, 1911), 2149 Sinton Ave., Walnut Hills, Cincinnati, O.

CROSS, Charles N. (1911), Instr., Mech. Engrg., Leland Stanford Jr. Univ., and 340 Embarcadero Rd., Palo Alto, Cal.

DALLAS, Park Andrew (1911), Mill Arch. and Engr., 1023 Candler Bldg., Atlanta, Ga.

DENNIS, Basil Wrenn (Junior, 1911), Asst. Ch. Engr., Muskogee Gas & Elec. Co., Muskogee, Okla., and *for mail*, 1165 E. Long St., Columbus, O.

DONNELLY, James A. (1911), Pres. and Genl. Mgr., Positive Differential System, and 132 Nassau St., New York, N. Y.

DOUGLAS, Walter Cooley (Junior, 1911), Asst. Engr. Mechanigraph Dept., Topping Bros., 122 Chambers St., New York, N. Y.

FLICKINGER, Harrison William (Junior, 1911), Thompson-Starrett Co., Second Natl. Bank Bldg., Pittsburg, Pa.

FORSBURG, Henry A. (1911), Genl. Supt. Trunk Lines, Stand. Oil Co. of Cal., and *for mail*, 1616 Josephine St., Berkeley, Cal.

HAWTHORNE, Primm R. (1911), Supt. of Design, Nichols & Shepard Co., Battle Creek, Mich.

HALL, Walter Atwood (1911), Asst. Mgr., Lynn Wks., Genl. Elec. Co., West Lynn, and *for mail*, 15 Hardy Rd., Swampscott, Mass.

HATMAN, Julius G. (Junior, 1911), Asst. Supt., The Wyandotte County Gas Co., and *for mail*, 746 Ann Ave., Kansas City, Kan.

HOWARD, Henry Sherwin (Junior, 1911), Cons. Engr., West. Fuel Co., and allied Cos., and *for mail*, 430 California St., San Francisco, Cal.

HUMPHREY, Charles Scranton (Junior, 1911), Asst. Electrician, C. W. Hunt Co., and *for mail*, 320 Bement Ave., West New Brighton, S. I., N. Y.

JAMIESON, Charles Clark (1911), Genl. Supt., Walter A. Wood Mowing & Reaping Mch. Co., Hoosick Falls, N. Y.

KLOCKARS, Charles Oscar (Associate, 1911), Factory Supt., Essex Fdy., and *for mail*, 51 Parkhurst St., Newark, N. J.

LAW, Frank E. (1911), V. P., The Fidelity & Casualty Co., New York, N. Y., and *for mail*, 322 Claremont Ave., Montclair, N. J.

LONGACRE, Fredk. v. D. (1911), Ingersoll-Rand Co., 11 Broadway, New York, N. Y.

MUNSON, Stanley (Junior, 1911), M.M., Oliver Chilled Plow Wks., and *for mail*, 1119 Michigan Ave., South Bend, Ind.

RENTSCHLER, Gordon Sohn (Junior, 1911), V. P. and Fdy. Mgr., The Hamilton Fdy. & Mch. Co., Hamilton, O.

RIEGE, Rudolph (1911), 58 Washington Ave., Stamford, Conn., and *for mail*, care of Henry Wilcox & Son, 828 Equitable Bldg., Denver, Colo.

SCHIEFER, Fred William (Junior, 1911), Mech. Engr., Lackawanna Bridge Co., and *for mail*, 60 W. Parade Ave., Buffalo, N. Y.

STANLEY, Frank A. (1911), West. Editor, American Machinist, and *for mail*, 3556 Monteith Ave., Hyde Park, Cincinnati, O.

VENESS, Alfred E. (1911), Factory Supt., Union Typewriter Co. Bridgeport, Conn.

WATTLES, Joseph Warren, 3d (Junior, 1910), Commer. Engr. Sales Dept., Edison Elec. Ill. Co., 39 Boylston St., Boston, Mass.

WHITNEY, William S. (1911), Supervising Engr., Am. Woolen Co., Boston, and 177 E. Haverhill St., Lawrence, Mass.

PROMOTION

de CAZENOVE, Louis A., Jr. (1905; 1911), Mech. Engr. and Asst. to Asst. Ch. Engr., Black Powder Dept., E. I. du Pont de Nemours Powder Co., and *for mail*, The Wilmington, Delaware Ave., Wilmington, Del.

DEATHS

HAGUE, Charles A., June 27, 1911.
HAYWOOD, D. Howard, July 5, 1911.
HUMPHREY, Charles S., June 29, 1911.
SCHUMANN, Francis, June 29, 1911.

COMING MEETINGS

August–September

Advance notices of annual and semi-annual meetings of engineering societies are regularly published under this heading and secretaries or members of societies whose meetings are of interest to engineers are invited to send such notices for publication. They should be in the editor's hands by the 15th of the month preceding the meeting. When the titles of papers read at monthly meetings are furnished they will also be published.

AMERICAN ASSOCIATION OF GENERAL PASSENGER AND TICKET AGENTS

September 19, annual meeting, St. Paul, Minn. Secy., C. M. Burt, Boston, Mass.

COLORADO ELECTRIC LIGHT, POWER AND RAILWAY ASSOCIATION

September 13–15, annual convention, Glenwood Springs, Colo. Secy., F. D. Morris, 323 Hagerman Bldg., Colorado Springs.

INTERNATIONAL ASSOCIATION ON MUNICIPAL ELECTRICIANS

September 12–15, annual meeting, St. Paul, Minn. Secy., C. R. George, Houston, Tex.

INTERNATIONAL CONGRESS OF THE APPLICATIONS OF ELECTRICITY

September 9–20, Turin, Italy. President of the Organizing Committee, L. Lombardi, 10, Via San Paolo, Milan.

INTERNATIONAL RAILROAD MASTER BLACKSMITHS' ASSOCIATION

August 15, annual meeting, Toledo, O. Secy., A. L. Woodworth, Lima.

NATIONAL ASSOCIATION OF COTTON MANUFACTURERS

September 27–30, semi-annual meeting, Hotel Equinox, Manchester, Vt. Secy., C. J. H. Woodbury, Box 3672, Boston, Mass.

NATIONAL BUILDING MATERIAL EXHIBITION

September 9–16, Trade Show, Madison Square Garden, New York. Mgr., P. J. Powers, 508 Flatiron Bldg.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION

September 12–15, annual meeting, St. Louis, Mo. Secy., W. E. Emery, P. & P. U. Ry., Peoria, Ill.

TRAVELING ENGINEERS' ASSOCIATION

August 29–September 2, annual convention, Hotel Sherman, Chicago, Ill. Secy., W. O. Thompson, care of N. Y. C. Car Shops, East Buffalo, N. Y.

VERMONT ELECTRICAL ASSOCIATION

September 13–14, annual meeting, Lake Dunmore, Vt. Secy., A. B. Marsden, Manchester.

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W. F. M. GOSS
ALEX. C. HUMPHREYS

Terms expire 1912
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Terms expire 1913
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Meetings

L. R. POMEROY (1), *Chmn.*
C. E. LUCKE (2)
H. DE B. PARSONS (3)
W. E. HALL (4)
C. J. H. WOODBURY (5)

Library

L. WALDO (1), *Chmn.*
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Public Relations

J. M. DODGE (5), *Chmn.*
R. W. HUNT (1)
D. C. JACKSON (2)
J. W. LIEB, JR. (3)
F. J. MILLER (4)

NOTE—Numbers in parentheses indicate number of years the member has yet to serve

SOCIETY REPRESENTATIVES

John Fritz Medal

[illegible]

[illegible]

[illegible]

[illegible]

Trustees U. E. S.

[illegible]

JESSE M. SMITH [illegible]

[illegible]

A. A. A. S.

[illegible]

[illegible]

[illegible]

CHARLES WHITING [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Engineering Education

[illegible]

F. W. TAYLOR

SPECIAL COMMITTEES

Refrigeration

[illegible]

Power Tests

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

Flanges

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

[illegible]

Pipe Threads

E. M. HERR, Chmn.

[illegible]

[illegible]

[illegible], JR.

Society History

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

New York, Chmn.

[illegible]

[illegible]

New York

[illegible]

San Francisco, Cal.

[illegible]

Boston, Mass.

[illegible]

[illegible], Chmn.

[illegible]

[illegible]

[illegible], Chmn.

[illegible]

OFFICERS OF AFFILIATED SOCIETY

Providence Association of Mechanical Engineers

[illegible]

[illegible]

[illegible]

OFFICERS OF THE GAS POWER SECTION

Chairman
R. H. FERNALD

Secretary
GEO. A. ORROK

Gas Power Executive Committee

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G. I. ROCKWOOD (1)
C. J. DAVIDSON (1)
E. D. DREYFUS (1)
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OFFICERS OF STUDENT BRANCHES

INSTITUTION	DATE AUTHORIZED BY COUNCIL	HONORARY CHAIRMAN	PRESIDENT	CORRESPONDING SECRETARY
Stevens Inst. of Tech.	Dec. 4, 1908	Alex. C. Humphreys	A. E. Bauhan	A. D. Karr
Cornell University	Dec. 4, 1908	R. C. Carpenter	F. E. Yoakem	D. S. Wegg, Jr.
Armour Inst. of Tech.	Mar. 9, 1909	G. F. Gebhardt	C. E. Beck	F. H. Griffiths
Leland Stanford Jr. Univ.	Mar. 9, 1909	C. H. Shattuck	H. H. Blee	C. W. Scholefield
Brooklyn Poly. Inst.	Mar. 9, 1909	W. D. Ennis	A. L. Palmer	R. C. Ennis
Purdue University	Mar. 9, 1909	L. V. Ludy	L. Jones	H. E. Sproull
University of Kansas	Mar. 9, 1909	P. F. Walker	W. H. Judy	M. C. Conley
New York University	Nov. 9, 1909	C. E. Houghton	Harry Anderson	Andrew Hamilton
Univ. of Illinois	Nov. 9, 1909	W. F. M. Goss	F. J. Schlink	E. J. Hasselquist
Penna. State College	Nov. 9, 1909	J. P. Jackson	J. A. Kinney	H. S. Rodgers
Columbia University	Nov. 9, 1909	Chas. E. Lucke	N. E. Hendrickson	J. L. Haynes
Mass. Inst. of Tech.	Nov. 9, 1909	Gaetano Lanza	J. A. Noyes	R. M. Ferry
Univ. of Cincinnati	Nov. 9, 1909	J. T. Faig	C. J. Malone	J. H. Schneider
Univ. of Wisconsin	Nov. 9, 1909	H. J. B. Thorkelson	F. B. Sheriff	L. F. Garlock
Univ. of Missouri	Dec. 7, 1909	H. Wade Hibbard	F. T. Kennedy	Osmer N. Edgar
Univ. of Nebraska	Dec. 7, 1909	C. R. Richards	W. O. Forman	C. A. Bennett
Univ. of Maine	Feb. 8, 1910	Arthur C. Jewett	A. H. Blaisdell	W. B. Emerson
Univ. of Arkansas	Apr. 12, 1910	B. N. Wilson	W. Q. Williams	H. W. Barton
Yale University	Oct. 11, 1910	L. P. Breckenridge	F. M. Jones	W. St. C. Childs
Rensselaer Poly. Inst.	Dec. 9, 1910	A. M. Greene, Jr.	G. K. Palsgrove	H. J. Parthesius
State Univ. of Ky.	Jan. 10, 1911	F. P. Anderson	G. C. Mills	H. L. Moore
Ohio State University	Jan. 10, 1911	W. T. Magruder	H. A. Shuler	H. M. Bone
Washington University	Mar. 10, 1911			F. E. Glasgow
Lehigh University	June 2, 1911			

MEETINGS OF THE SOCIETY

The Committee on Meetings

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Meetings of the Society in New York

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Meetings of the Society in St. Louis

E. L. OHLE, *Chmn.* M. L. HOLMAN
F. E. BAUSCH, *Secy* R. H. TAIT
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Meetings of the Society in San Francisco

A. M. HUNT, *Chmn.* T. MORRIN
T. W. RANSOM, *Secy.* W. F. DURAND
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Meetings of the Society in Philadelphia

T. C. McBRIDE, *Chmn.* A. C. JACKSON
D. R. YARNALL, *Secy.* J. E. GIBSON
W. C. KERR J. C. PARKER
JAMES CHRISTIE

Meetings of the Society in New Haven

E. S. COOLEY, *Chmn.* L. P. BRECKENRIDGE
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SUB-COMMITTEES ON

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JOHN ECCLES, Taftville, Conn. C. R. MAKEPEACE, Providence, R. I.
EDW. W. FRANCE, Philadelphia, Pa. C. H. MANNING, Manchester, N. H.
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EDWARD W. THOMAS, Lowell, Mass.

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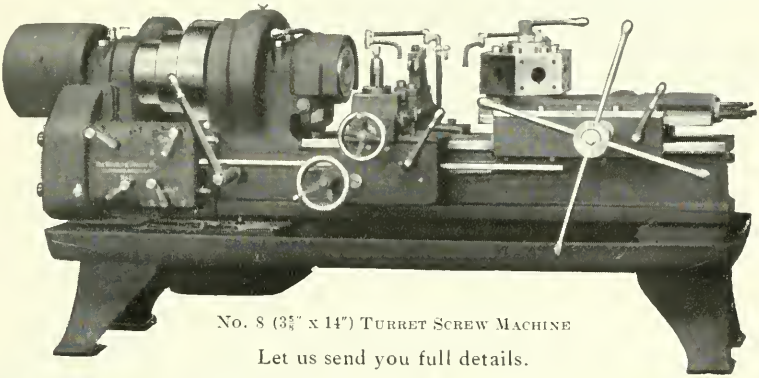

No. 8 (3⅝" x 14") Turret Screw Machine

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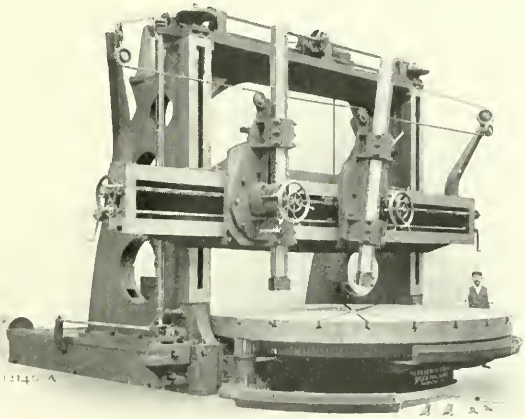

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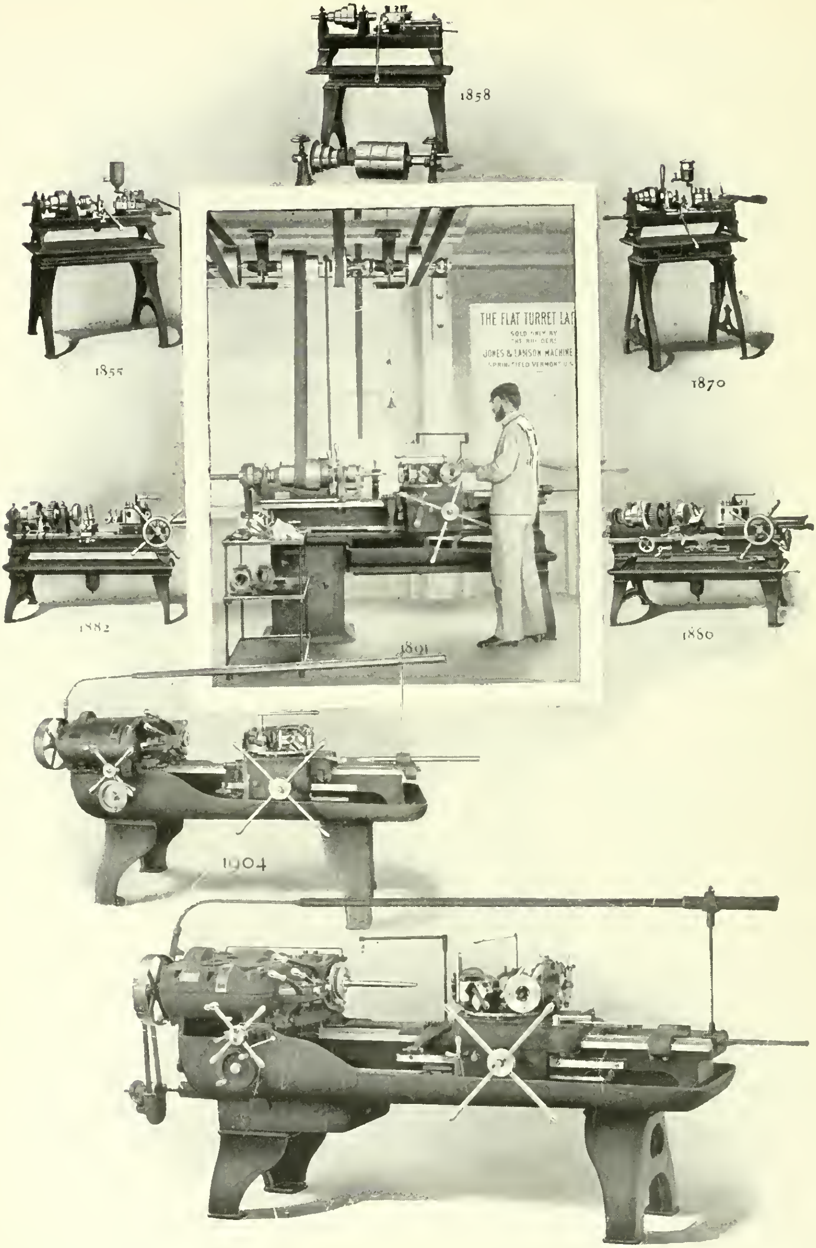
HARTNESS FLAT TURRET LATHE



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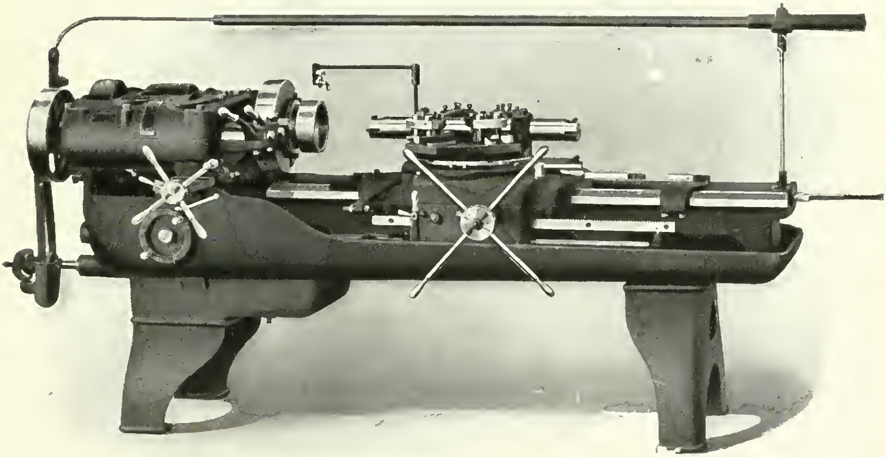

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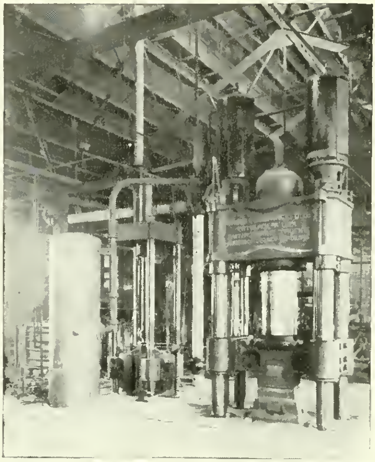

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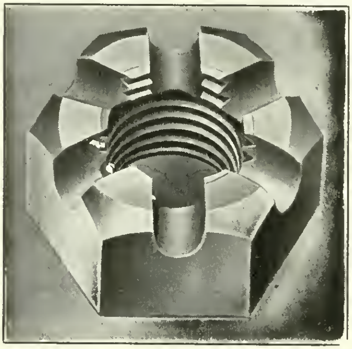

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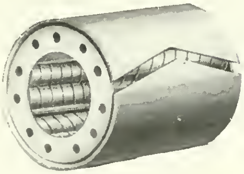

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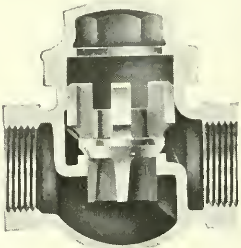

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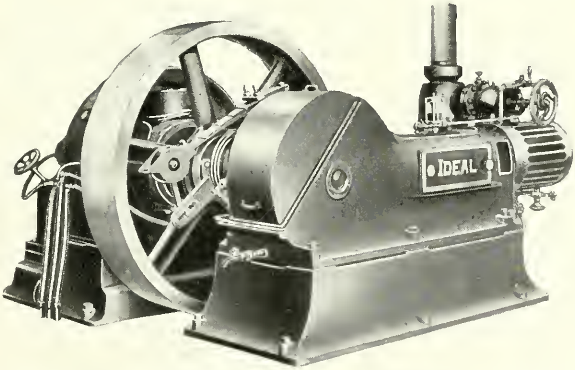

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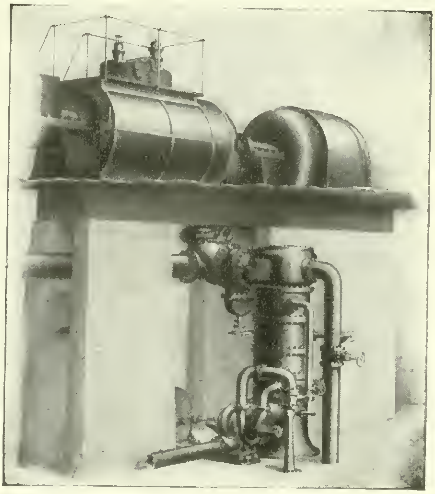

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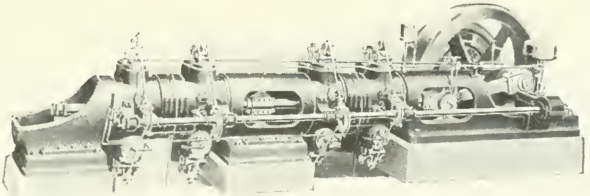

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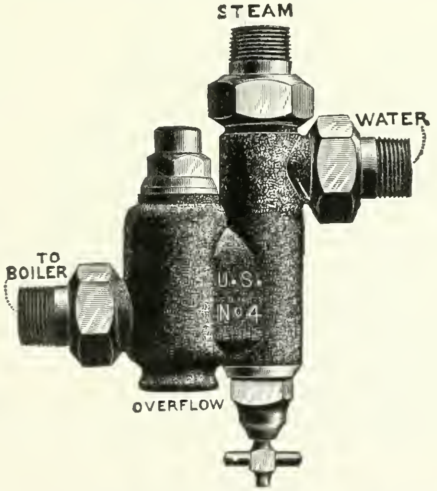

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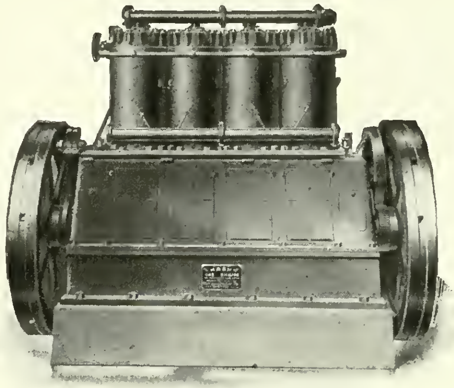

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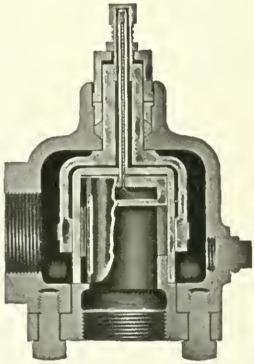

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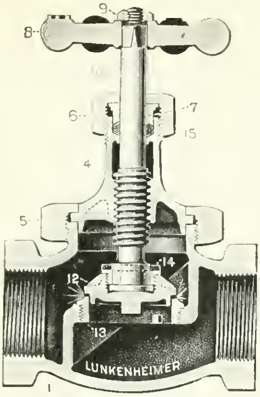

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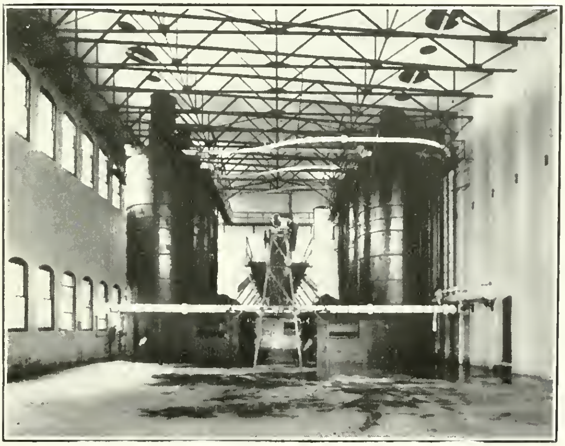

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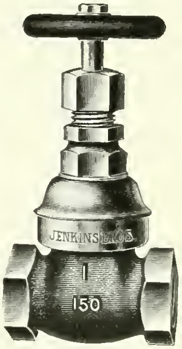

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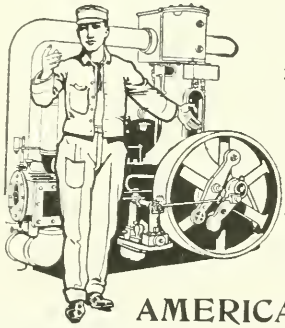

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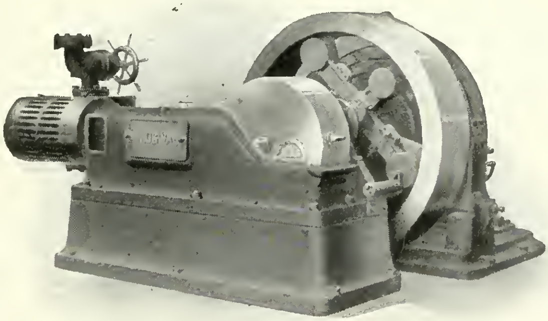

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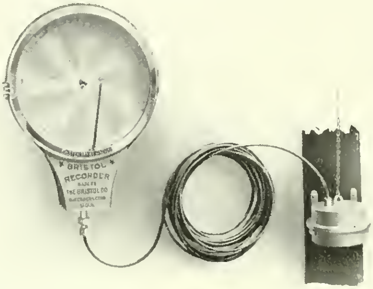

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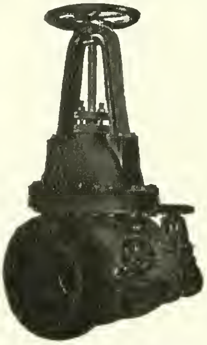

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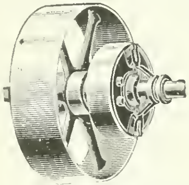

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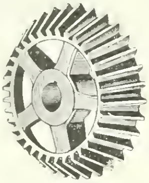

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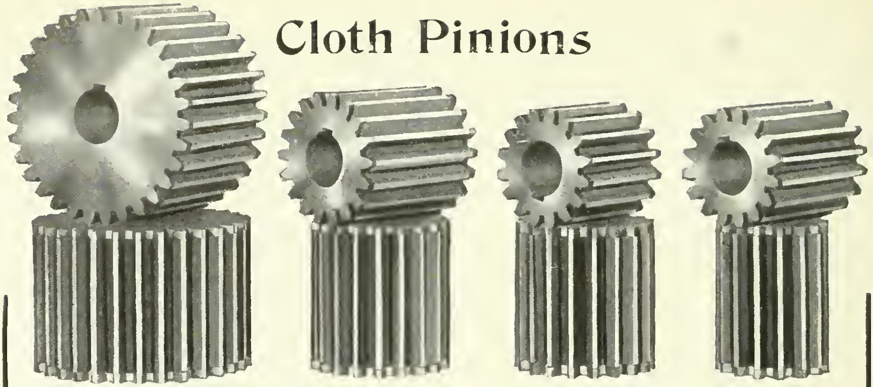

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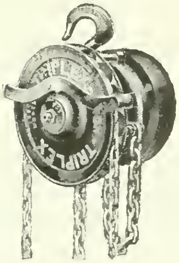

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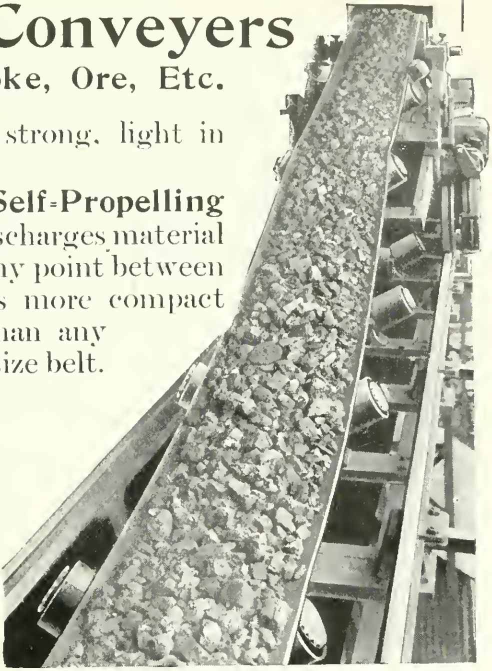

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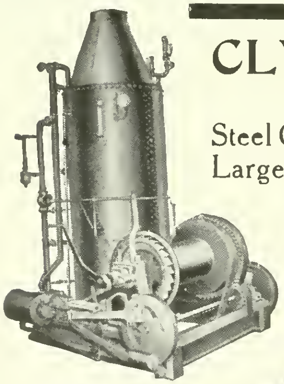

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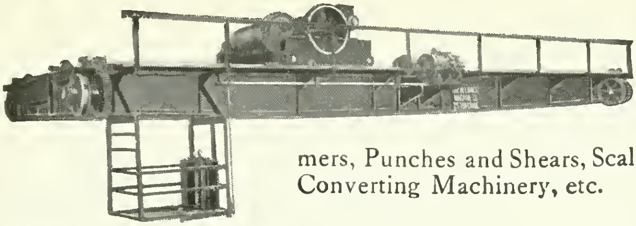

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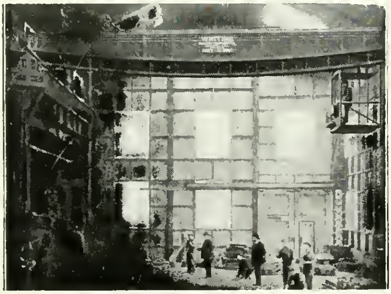

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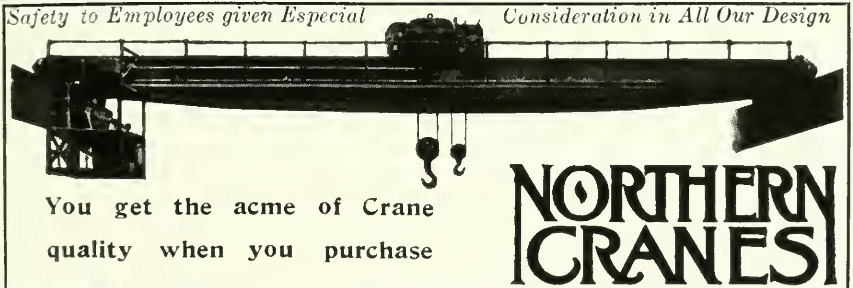

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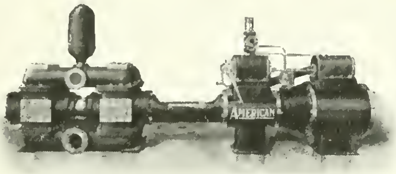

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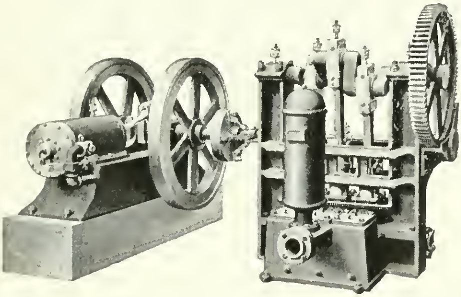

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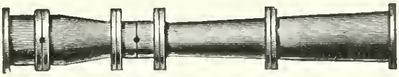

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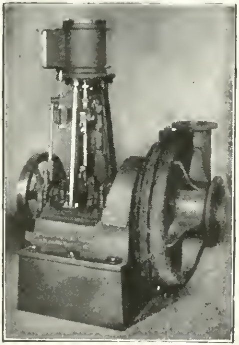

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